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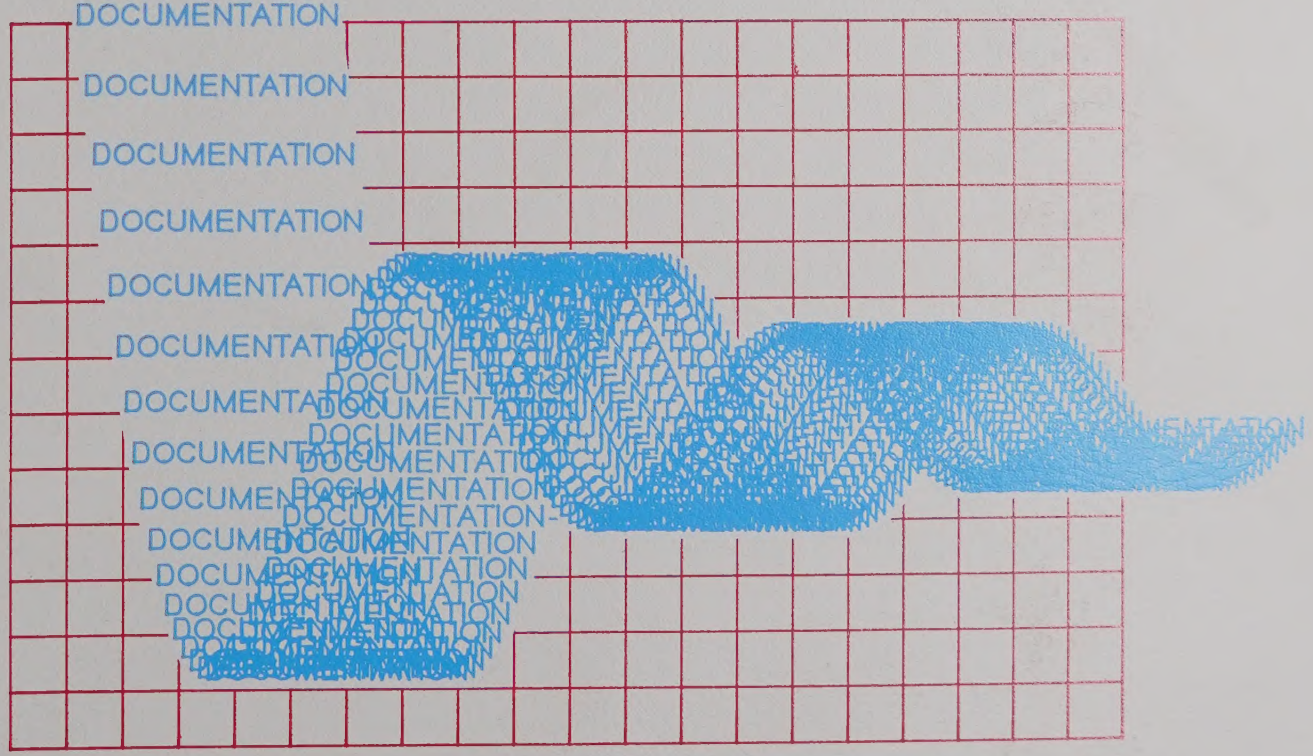

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Software Manual

Software for Measurement of Noise Figure and Gain

FS-K3

1057.3028.02

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ISO 9001

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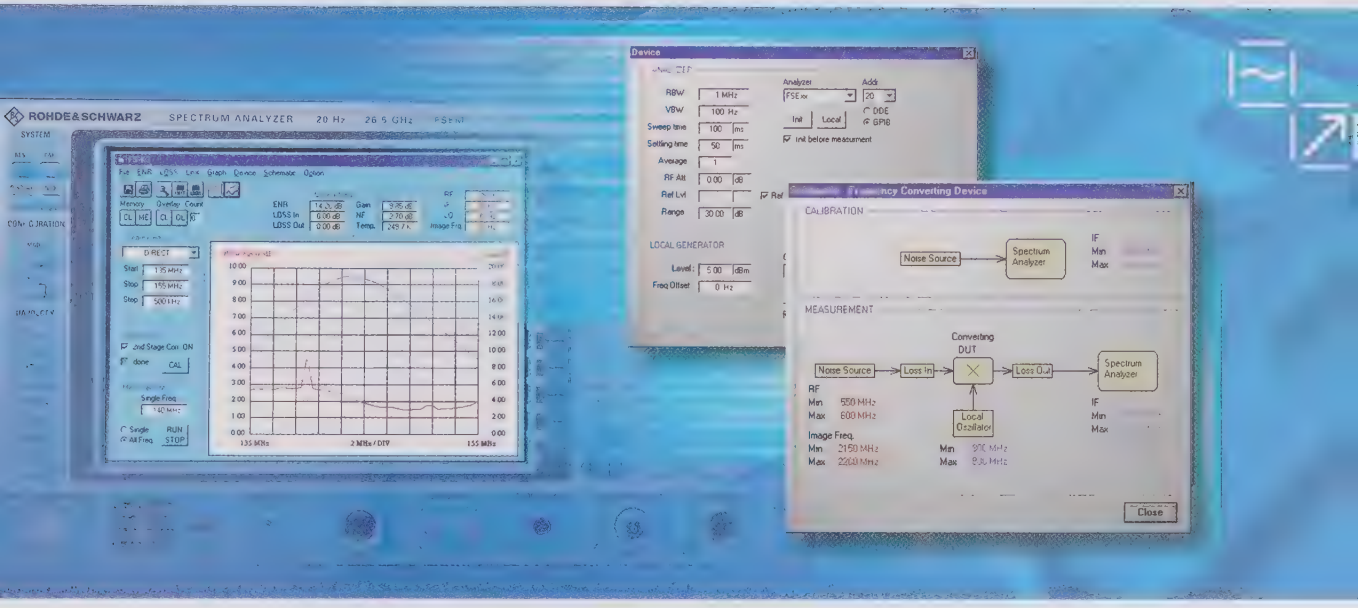

Noise Measurement Software FS-K3 for Spectrum Analyzers FSE, FSIQ and FSP

Outperforming any conventional noise measurement system

Spectrum Analyzers FSE and FSP as well as Signal Analyzers FSIQ from Rohde &Schwarz feature high sensitivity and level accuracy – in conjunction with switchable, calibrated noise sources – and are thus ideal for automatic measurement of noise figure and gain.

Noise Measurement Software FS-K3 provides the high-grade analyzers with features otherwise only offered by special noise measurement systems. At a given frequency or in a selectable frequency range the following parameters can be measured:

- Noise figure in dB
- Noise temperature in K
- Gain in dB

FS-K3 used with Analyzers FSE, FSIQ or FSP has the advantage over conventional noise measurement systems that a large variety of further RF measurements can also be performed.

The measurement results are output as a graph or a list. Up to eight measurements can be represented in a diagram.

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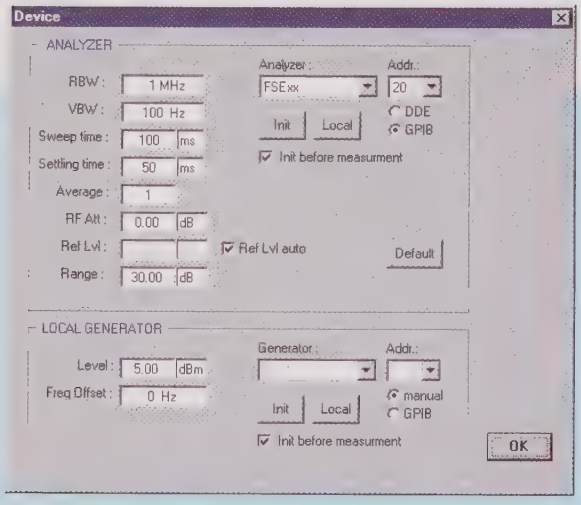
Noise Measurement Software FS-K3 ...

1



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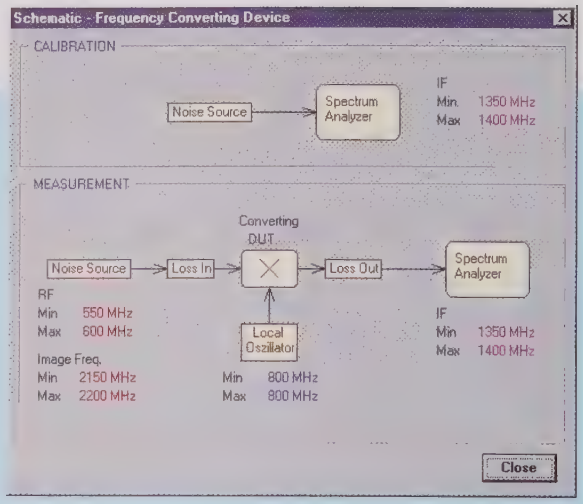

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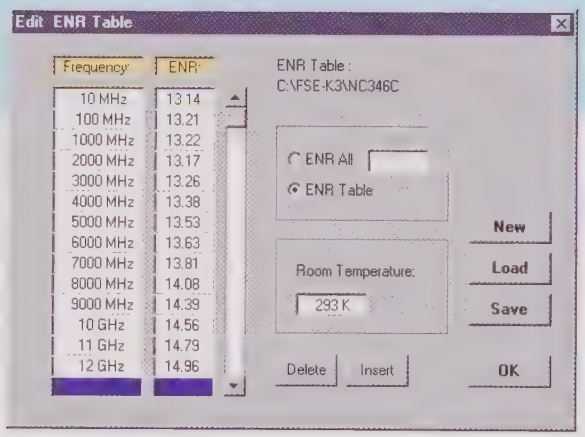


4

The combination of Noise Measurement Software FS-K3 and Analyzers FSE, FSIQ or FSP offers the following advantages over conventional noise measurement systems:

- Frequency range up to 26.5 GHz (depending on analyzer model) for noise measurements in the microwave range without need for an additional downconverter
- Resolution bandwidths variable in steps of 1/2/3/5 (FSP: 1/3) for optimum matching to narrowband DUTs

While conventional noise measurement systems are only suitable for determining the noise and gain characteristics of the DUT, FSE or FSIQ also allows the highly sensitive measurement of:

- harmonics
- intermodulation
- spurious responses

and of many other RF-relevant criteria.

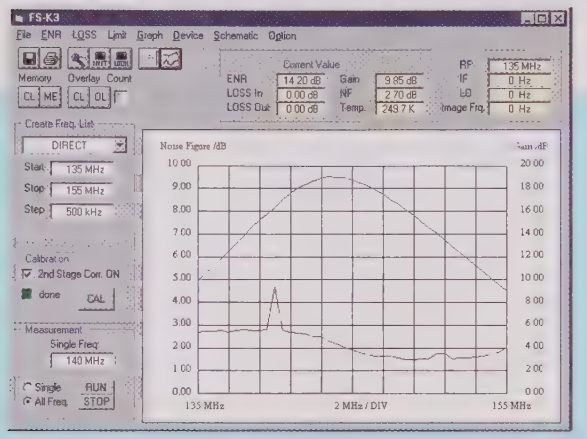
The versatility of this FSE/FSIQ/FSP-based noise measurement set is not at the expense of the measurement accuracy, which essentially is determined by the accuracy of the noise source calibration and the mismatch. The largest error affecting the measuring instrument, ie the linearity of its log characteristic, is minimized in Analyzers FSE, FSIQ and FSP by individual calibration.

Easy to operate

FS-K3 runs under the operating systems Windows 3.1, Windows 95 and Windows NT. The software for controlling the analyzer can be run on a Spectrum Analyzer FSE in conjunction with Computer Function FSE-B15, on a Signal Analyzer FSIQ (which includes Windows NT as standard) or on a Spectrum Analyzer FSP via an internal interface, or on a PC via the IEEE bus. Windows ensures easy and familiar operation. The measurement results

... outperforming conventional noise measurement systems

5



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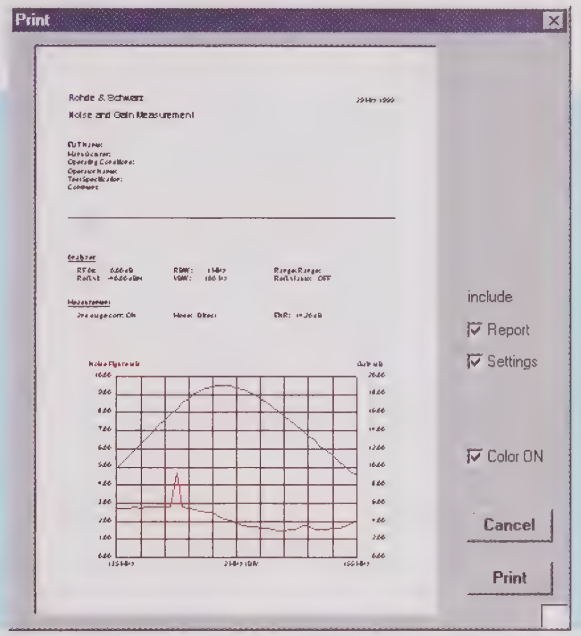

1 to 3 The familiar Windows user interface makes for convenient settings

4 Spectrum Analyzer FSE, an external PC and the power supply for the DUT: this is all you need to set up an extremely convenient measurement system for noise and many other parameters

5 Measurements on a GaAs preamplifier show an anomaly at 140 MHz, whose cause is easily traceable in the spectrum analyzer mode

6 The documentation of results includes instrument setups and DUT description

can be further processed, eg for documentation or presentation, using Windows standard software.

An unlimited number of complete measurement routines can be stored. They facilitate reproducible and error-free measurements and include:

- Frequency range
- Noise source characteristics
- Type of DUT (amplifier, mixer, low-noise converter)
- Analyzer settings
- Measurement results

Applications

Highly sensitive measurements on amplifiers

Noise figure measurements respond even to very small disturbances. In example (5) measurements are carried out on a GaAs preamplifier showing an irregularity at 140 MHz.

The interference source can be detected and eliminated with an Analyzer FSE, FSIQ or FSP. The analysis of the disturbed frequency range is made easily by switching to the spectrum analyzer mode.

Measurements on frequency-converting DUTs, eg low-noise converters

FS-K3 allows the noise figure and the gain for instance of LNCs for direct satellite reception to be measured without any problems despite the great frequency difference of typ. 10 GHz between the input and output. A particular asset in these measurements is the extremely wide dynamic range, allowing the direct determination of gain values up to 60 dB. Even higher values can be measured when the DUT is followed by an attenuator, which is taken into account automatically. The software supports measurements on frequency-converting DUTs using a fixed LO frequency or a fixed IF. It allows the user to select the sidebands to be measured and controls external generators for mixer measurements via the IEEE bus. To control a signal generator when using FSP, Noise Measurement Software FS-K3 has to be installed on an external process controller. A graphic overview assists the user in frequency setting (2).

Specifications

Frequency range	100 kHz to 26.5 GHz (depending on analyzer model)
Measurement bandwidth	1 kHz to 5 MHz
Noise measurements	
Level range	0 to 25 dB
Resolution	0.01 dB
Measurement accuracy	±0.2 dB (preamplification 20 dB, noise figure 5 dB, bandwidth 1 MHz)
Gain measurements	
Level range	0 to 60 dB
Resolution	0.01 dB
Measurement accuracy	±0.2 dB (preamplification 20 dB, noise figure 5 dB, bandwidth 1 MHz)

Required hardware and software

Analyzers	FSEA, FSEB, FSEM FSIQ3, FSIQ7, FSIQ26 or FSP3, FSP7, FSP13, FSP30
Recommended noise source	NoiseCom 346 (see Table below)
Power supply	via 28 V connector on rear panel of FSE/FSIQ/FSP (BNC)
Preamplifier	gain approx. 20 dB, noise figure max. 5 dB

Control via external PC/IEEE bus	
CPU	80 486 or better
RAM	≥4 Mbyte
Graphics card	VGA or better
Software	Windows 3.1, Windows 95 or NT
Interface	IEC 625-1 (IEEE 488)
Interface card	National Instruments AT/TNT/PC card
Control via FSE	
Required option	Computer Function FSE-B15 (DDE interface of Windows)
Control via FSIQ	no options required
Control via FSP	keyboard PSP-Z2

Ordering information

Order designation		
Noise Measurement Software	FS-K3	1057.3028.02
Options		
Computer Function for FSE (Window NT)	FSE-B15	1073.5696.06
2nd IEC/IEEE-Bus Interface	FSE-B17	1066.4017.02
Noise source	see Table below	

Note: FSE with FSE-B15 or FSIQ requires the optional 2nd IEC/IEEE-bus interface to control a signal generator (eg SMIQ) in case of mixer measurements.

Certified Quality System ISO 9001 DQS REG. NO 1954-04

Certified Environmental System ISO 14001 REG. NO 1954

Noise source*	RF connector	Frequency range (GHz)	Output level (dB)	VSWR (max. upon ON/OFF) 0.01 to 5 GHz	VSWR (max. upon ON/OFF) 5 to 18 GHz
NC 346 A	SMA male	0.01 to 18	5 to 7	1.15:1	1.25:1
NC 346 A Precision	APC 3.5 male	0.01 to 18	5 to 7	1.15:1	1.25:1
NC 346 A Option1	N male	0.01 to 18	5 to 7	1.15:1	1.25:1
NC 346 A Option 2	APC 7	0.01 to 18	5 to 7	1.15:1	1.25:1
NC 346 A Option 4	N female	0.01 to 18	5 to 7	1.15:1	1.25:1
NC 346 B	SMA male	0.01 to 18	14 to 16	1.15:1	1.25:1
NC 346 B Precision	APC 3.5 male	0.01 to 18	14 to 16	1.15:1	1.25:1
NC 346 B Option 1	N male	0.01 to 18	14 to 16	1.15:1	1.25:1
NC 346 B Option 2	APC 7	0.01 to 18	14 to 16	1.15:1	1.25:1
NC 346 B Option 4	N female	0.01 to 18	14 to 16	1.15:1	1.25:1
NC 346 C	APC 3.5 male	0.01 to 26.5	13 to 17	1.15:1	1.25:1 1.35:1 (18 to 26.5 GHz)
NC 346 D	SMA male	0.01 to 18	19 to 25	1.5:1	1.5:1
NC 346 D Precision	APC 3.5 male	0.01 to 18	19 to 25	1.5:1	1.5:1
NC 346 D Option 1	N male	0.01 to 18	19 to 25	1.5:1	1.5:1
NC 346 D Option 2	APC 7	0.01 to 18	19 to 25	1.5:1	1.5:1
NC 346 D Option 3	N female	0.01 to 18	19 to 25	1.5:1	1.5:1
NC 346 E	APC 3.5 male	0.01 to 26.5	19 to 25	1.5:1	1.5:1 1.5:1 (18 to 26.5 GHz)

* Noise sources supplied by NoiseCom; specifications from NoiseCom

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1 Introduction

The ROHDE & SCHWARZ FS-K3 is an application software for Microsoft Windows that extends the Spectrum Analyzer Family FSP, FSE, FSIQ, ESI to a test set for noise figure measurements.

This introduction treats the following subjects:

- Information on the manual
- Using the analyzer for the noise measurement
- Installing, starting and terminating FS-K3

Information on this Manual

This manual supports you when working with the FS-K3. It helps you to prepare, perform and evaluate a measurement and provides you with a great number of helpful hints and examples.

To allow you to quickly familiarize yourself with the FS-K3, the FS-K3 manual has been divided into Quick Start and a reference part (chapters 3 to 7). The chapter Quick Start leads you step by step through an ordinary noise figure measurement.

The goal of this chapter is the fast familiarization of the user.

A detailed description of all functions and capabilities of the FS-K3 is to be found in chapters 3 to 7. In addition, the noise measurement and the various methods of measurement will also be dealt with.

This chapter serves as guide and reference.

Using the Analyzer for the Noise Measurement

The use of an FSE spectrum analyzer with its high sensitivity and level accuracy enables the accurate and reproducible measurement of the noise figure, e.g. of low-noise FET amplifier circuits with noise figures < 1 dB. Compared with special noise measuring instruments, the properties of the analyzer as indicator are considerably useful for this purpose.

- By varying the IF filter bandwidth, an accurate measurement is also possible in the case of narrowband DUTs.
- The free selection of the sweep number and sweep time for the level measurement also permits to determine the noise figure (and even the gain) of the DUT even at low frequencies.
- The high dynamic range of the analyzer enables measurements on highly amplifying DUTs.
- The frequency range of the analyzer can virtually be fully utilized as measurement range without conversion.

Installation of the FS-K3

Before starting the FS-K3 make sure that your computer meets the minimum requirements for operation.

Hardware and Software Requirements for FS-K3

- An IBM-compatible personal computer with a processor of the type 80386 or higher.
- A hard disk with at least 4 MB available memory area
- A Microsoft mouse or a compatible pointing device.
- An EGA, VGA or compatible display (VGA or higher is recommended)
- A correctly installed IEC-bus interface.(PS-B4 or National Instruments)
- At least 4 MB main memory.
- Microsoft Windows, version 3.11 or higher, Windows 95/98/NT. (NT is recommended)
- A spectrum analyzer of the ROHDE & SCHWARZ FSE family, firmware version 1.40 or higher or ESI/FSIQ.
- A spectrum analyzer of the ROHDE & SCHWARZ FSP family, firmware version 1.50 or higher.
- A noise source switchable with 28 V (e.g. NoiseCom 346B).

Setting up and Starting the FS-K3

To install the FS-K3 on your computer use the Setup program (SETUP.EXE).

Installing the FS-K3

- Start Microsoft Windows.
- Insert the program disk into drive A.
- Select the **Execute** command from the **File** menu in the Windows program manager.
- Enter `a:setup` in the *command line.*
- Click on the "OK" button.
- Follow the installation instructions on the screen.

After the required files have been installed, the setup program creates the program group FS-K3 and inserts the symbol for the FS-K3.

Special Features when Installing the FS-K3 Software on an FSE Analyzer

If your FSE analyzer is equipped with an internal computer option, no external PC will be required and your analyzer will constitute an independent noise test set. However, observe the following items when installing the software.

- Switch over the FSE display to the computer function using the key combination **ALT+print**
- Start Windows
- Insert the program disk into drive A.
- Select the **Execute** command from the **File** menu in the Windows program manager.
- Enter `a:setup` in the *command line.*
- Click on the "OK" button.
- Observe the installation instructions on the screen.
- Delete the files RSDDE.DLL and RSIB.DLL, if present, from the directories C:\WINDOWS or C:\WINNT and C:\FS-K3 or from the working directory of the FS-K3 Software (if available).
- Copy the files D:\RUNTIME\RSIB\RSDDE.DLL and D:\RUNTIME\RSIB\RSIB.DLL into the directory C:\WINDOWS\SYSTEM or on Windows NT C:\R_S\INSTR\RSIB\RSIB.DLL into the directory C:\WINNT\SYSTEM.
- Set the selector switch to *DDE* in the *Device* menu (see chapter 4, Device Setting)

Notes for Windows/NT

When using Windows-NT it is recommended to start the program in an extra memory area. This leads to an enormous increase in speed when the individual windows are built up. Under Windows-NT, an option switch is provided for this purpose under Properties.

Calling up:

- Click on the icon using the right mouse key.
- Click on Properties
- Click on Short cut
- Activate Run In Separate Memory Space

To start the FS-K3

- Open the program group containing the symbol for FS-K3 in the Windows program manager.
- Double-click on the symbol for FS-K3.
- FS-K3 is started and the FS-K3 window opened.
- When starting the program for the first time, it is necessary to enter the code supplied with the FS-K3. Code is printed on the disc label.
- When calling up the program at a later point in time, this code is no longer required, and the program immediately appears with the main menu.

Terminating the FS-K3

- Select the **Exit** command from the **File** menu or press the key combination **ALT+F4.**
- Before terminating the program it is possible to save all settings including the measurement results. If you wish to do so, click on the YES button. When calling up the FS-K3 again, the data will all be there again and you can immediately continue the measurement. The software FS-K3 is terminated.

Special Features when Installing the FS-K3 Software on an FSP Analyzer

If your FSP analyzer is suitably configured, no external PC will be required for noise measurements and your analyzer will constitute an independent noise test set.

To install and operate the FS-K3 software a PS/2 keyboard is necessary eg PSP-Z2 (Order No. 1091.4100.02). When using other type of keyboards without built-in rollkey it is recommended to connect a PS/2 mouse to the rear of the analyzer. Do not connect keyboard and mouse with the power switched on.

Prior to the installation of FS-K3 the internal connections between FS-K3 and the analyzer must be ensured:

- **Installation of network card driver** (with built-in option FSP-B16 this is already included in the installation of option)
- **Installation of TCP/IP network protocol**
- **Installation of RSIB interface libraries**.

Note: *The WINDOWS NT files required for the installation of network drivers, protocols and services are located in the "C:\I386" directory.*

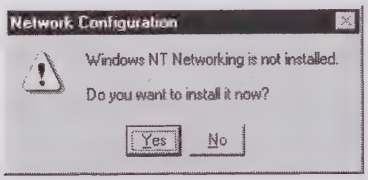
Installation of the network card driver for analyzers without the LAN interface option

The basic prerequisite for the installation of the TCP/IP protocol is that a network card driver is built in. In the absence of such a card a so-called loopback adapter takes over for the missing function. The adapter is part of the Windows NT.

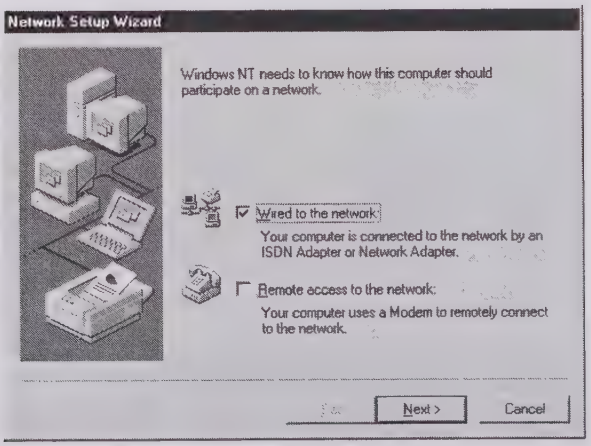
The installation procedure is as follows after the power-up of the analyzer and start of the firmware:

➢ Open the start menu of Windows NT with the key combination <**CTRL>-<ESC>** .

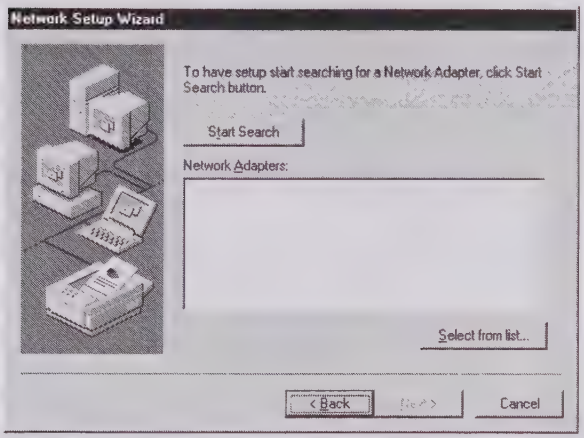
➢ Select menu items **SETTINGS – CONTROL PANEL – NETWORK.**



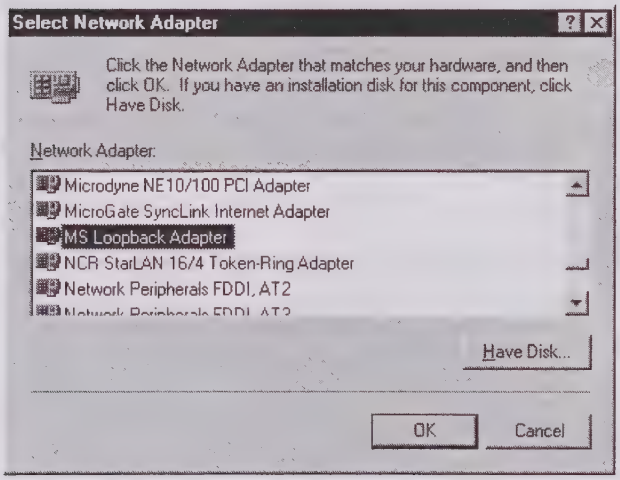
➢ Answer the question "Do you want to install it now?" with "Yes".


Network Setup Wizard
Windows NT needs to know how this computer should participate on a network.
Wired to the network
Your computer is connected to the network by an ISDN Adapter or Network Adapter.
Remote access to the network:
Your computer uses a Modem to remotely connect to the network.
Next >
Cancel

➢ Leave the presetting "Wired to the network" unchanged and confirm with "NEXT".

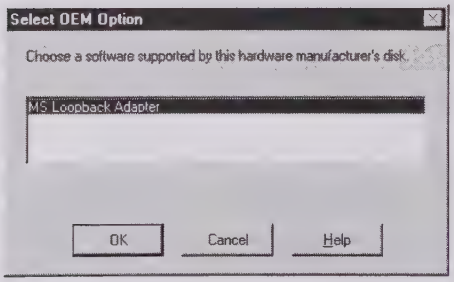

Network Setup Wizard
To have setup start searching for a Network Adapter, click Start Search button.
Start Search
Network Adapters:
Select from list...
< Back
Next >
Cancel

➢ Choose a network card by clicking "Select from list".


Select Network Adapter
Click the Network Adapter that matches your hardware, and then click OK. If you have an installation disk for this component, click Have Disk.
Network Adapter:
Microdyne NE10/100 PCI Adapter
MicroGate SyncLink Internet Adapter
MS Loopback Adapter
NCR StarLAN 16/4 Token-Ring Adapter
Network Peripherals FDDI, AT2
Have Disk...
OK
Cancel

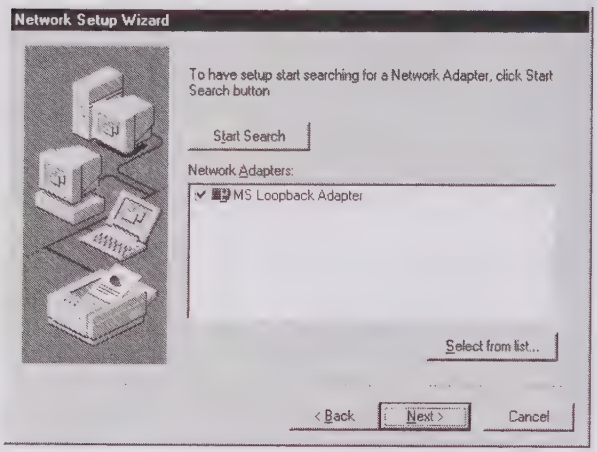
The OEM options appear.

➢ Click MS Loopback Adapter and confirm with OK.



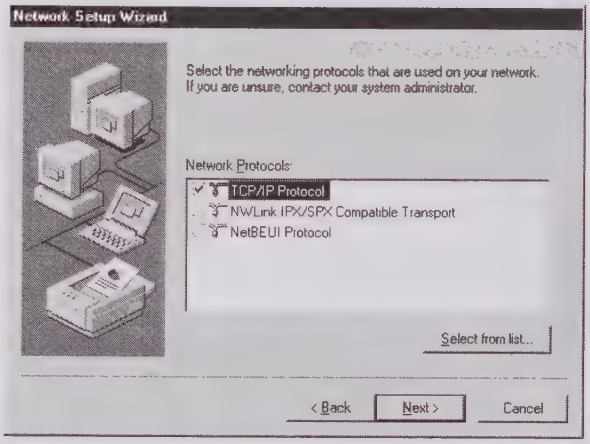
- If "Loopback" has already been selected, this select box appears:
- Confirm "MS Loopback Adapter" with "OK"

.



➢ Leave dialog with "MS Loopback Adapter" selected using "NEXT".

Installation of TCP/IP network protocol

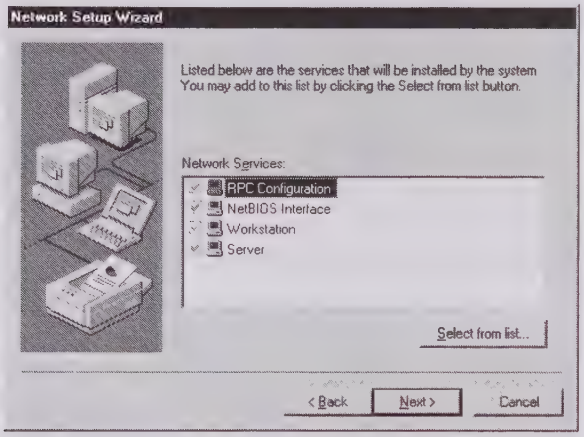

Network Setup Wizard
Select the networking protocols that are used on your network. If you are unsure, contact your system administrator.
Network Protocols:
TCP/IP Protocol
NWLink IPX/SPX Compatible Transport
NetBEUI Protocol
Select from list...
< Back
Next >
Cancel

➢ Select TCP/IP protocol and confirm with "NEXT".

Selection of network services

To be able to use the network resources it is necessary to install the corresponding services.

Note: *The network administrator knows which services are to be installed.*

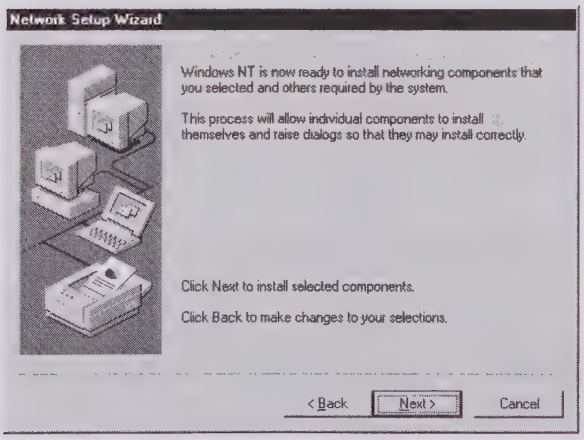

Network Setup Wizard
Listed below are the services that will be installed by the system
You may add to this list by clicking the Select from list button.
Network Services:
RPC Configuration
NetBIOS Interface
Workstation
Server
Select from list...
< Back
Next >
Cancel

➢ The selected services cannot be changed when installing for the first time.

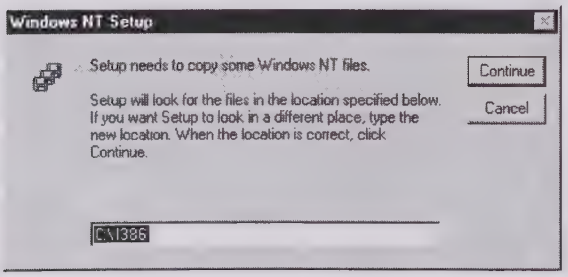
Further services may be added after the installation.

➢ Continue with "NEXT".

Termination of the installation

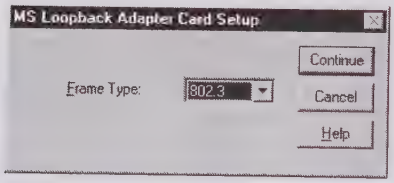

Network Setup Wizard
Windows NT is now ready to install networking components that you selected and others required by the system.
This process will allow individual components to install themselves and raise dialogs so that they may install correctly.
Click Next to install selected components.
Click Back to make changes to your selections.
< Back
Next >
Cancel

➢ Initiate installation by clicking "NEXT".


Windows NT Setup
Setup needs to copy some Windows NT files.
Setup will look for the files in the location specified below. If you want Setup to look in a different place, type the new location. When the location is correct, click Continue.
Continue
Cancel
C:\I386

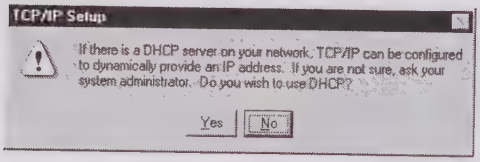
➢ Enter drive "C:\I386" and click "Continue".

A message box for selecting the frame type is opened.



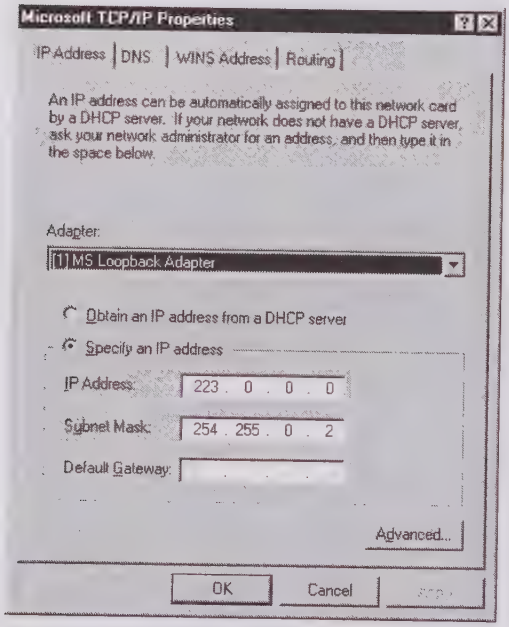
- Select Frame Type "802.3" and confirm with "Continue".

The dialog for selecting the TCP/IP properties is opened.


TCP/IP Setup
If there is a DHCP server on your network, TCP/IP can be configured to dynamically provide an IP address. If you are not sure, ask your system administrator. Do you wish to use DHCP?
Yes
No

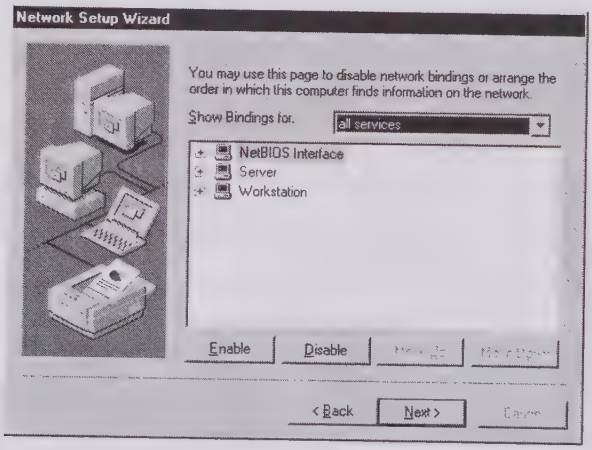
- Answer the question on the use of DHCP with "No".

The TCP/IP protocol is now installed.

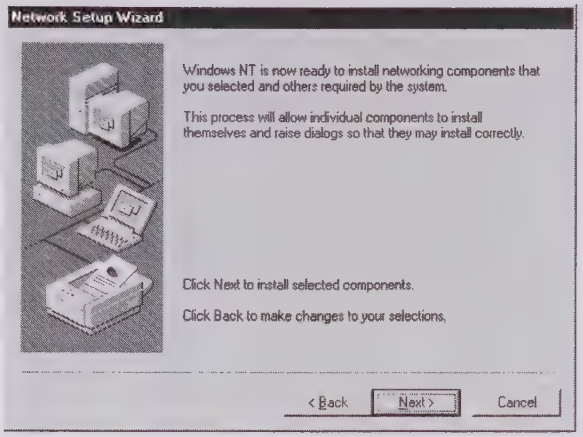

Microsoft TCP/IP Properties
IP Address
DNS
WINS Address
Routing
An IP address can be automatically assigned to this network card by a DHCP server. If your network does not have a DHCP server, ask your network administrator for an address, and then type it in the space below.
Adapter:
[1] MS Loopback Adapter
Obtain an IP address from a DHCP server
Specify an IP address
IP Address:
223 . 0 . 0 . 0
Subnet Mask:
254 . 255 . 0 . 2
Default Gateway:
Advanced...
OK
Cancel

- Do not change the selection of "Adapter".
- Click "Specify an IP address" .
- Enter IP address "223 . 0 . 0 . 0" and Subnet Mask "254 . 255 . 0 . 2".
- Leave dialog with OK.

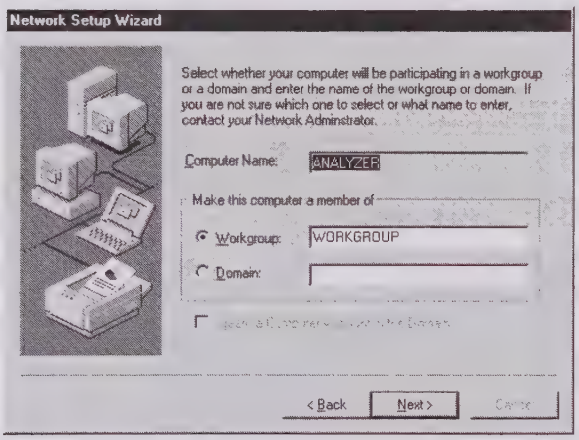
The Network Bindings display is opened.


Network Setup Wizard
You may use this page to disable network bindings or arrange the order in which this computer finds information on the network.
Show Bindings for:
all services
NetBIOS Interface
Server
Workstation
Enable
Disable
< Back
Next >

- Do **not** change the setting and leave dialog with "Next".

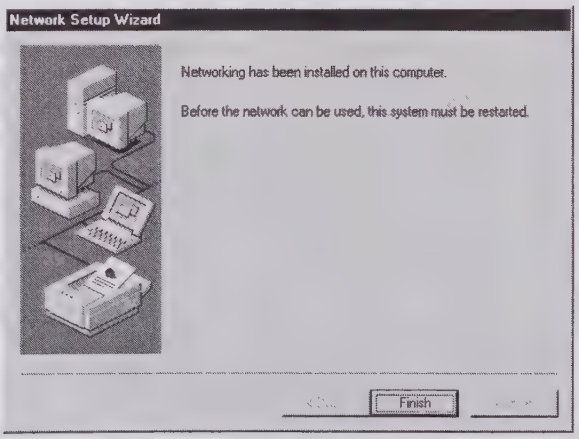

Network Setup Wizard
Windows NT is now ready to install networking components that you selected and others required by the system.
This process will allow individual components to install themselves and raise dialogs so that they may install correctly.
Click Next to install selected components.
Click Back to make changes to your selections.
< Back
Next >
Cancel

➢ Initiate the installation by clicking "Next".

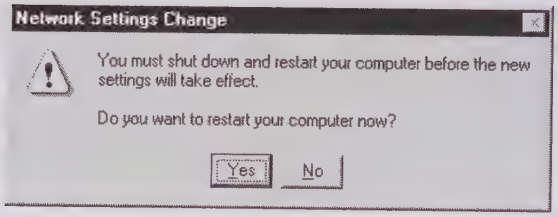

Network Setup Wizard
Select whether your computer will be participating in a workgroup or a domain and enter the name of the workgroup or domain. If you are not sure which one to select or what name to enter, contact your Network Administrator.
Computer Name:
ANALYZER
Make this computer a member of
Workgroup:
WORKGROUP
Domain:
< Back
Next >

➢ The preset computer and workgroup names "ANALYZER" and "WORKGROUP" can be confirmed with "NEXT".

Note:
The computer name in Windows network must be unambiguous.


Network Setup Wizard
Networking has been installed on this computer.
Before the network can be used, this system must be restarted.
Finish

➢ Terminate installation by clicking "Finish".

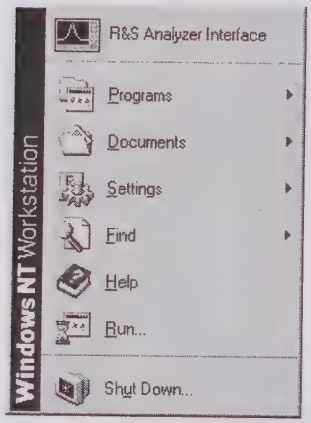

Network Settings Change
You must shut down and restart your computer before the new settings will take effect.
Do you want to restart your computer now?
Yes
No

➢ Answer the query "You must shutdown..." with "No" since after the installation of the network driver the "Service Pack 5" from Windows NT must be installed again.

➢ Close Control Panel by entering <ALT><F4>.

Re-installation of Service Pack

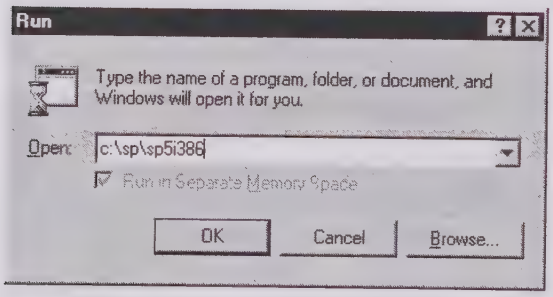
The installation of the Service Pack has to be repeated to avoid error messages "One or more services could not be started ..." occurring during booting.



➢ Open the start menu of Windows NT with the key combination <CTRL><ESC> .

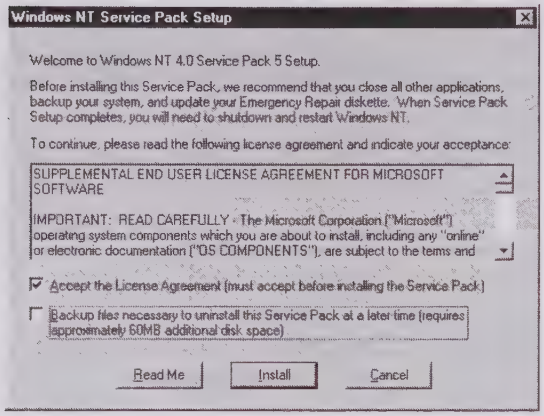
➢ Select item "RUN".

The input field for the program to be executed appears.



➢ Enter the command "C:\SP\SP5i386" conclude with OK.

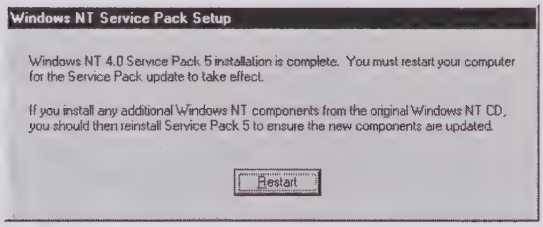
The installation of the Service Pack begins with the unpacking of the associated files.


Windows NT Service Pack Setup
Welcome to Windows NT 4.0 Service Pack 5 Setup.
Before installing this Service Pack, we recommend that you close all other applications, backup your system, and update your Emergency Repair diskette. When Service Pack Setup completes, you will need to shutdown and restart Windows NT.
To continue, please read the following license agreement and indicate your acceptance:
SUPPLEMENTAL END USER LICENSE AGREEMENT FOR MICROSOFT SOFTWARE
IMPORTANT: READ CAREFULLY - The Microsoft Corporation ("Microsoft") operating system components which you are about to install, including any "online" or electronic documentation ("OS COMPONENTS"), are subject to the terms and
Accept the License Agreement (must accept before installing the Service Pack)
Backup files necessary to uninstall this Service Pack at a later time (requires approximately 60MB additional disk space)
Read Me
Install
Cancel

- Answer the question on user licence agreement with "Accept the License Agreement..."
- Remove marking at "Backup files necessary..." and conclude with "Install".

The files of the Service Pack are now installed.

***Note**:*
Backup of the files replaced by the Service Pack is not required.


Windows NT Service Pack Setup
Windows NT 4.0 Service Pack 5 installation is complete. You must restart your computer for the Service Pack update to take effect.
If you install any additional Windows NT components from the original Windows NT CD, you should then reinstall Service Pack 5 to ensure the new components are updated.
Restart

Once the installation is complete the request for restarting the instrument appears.

- Click the "Restart" button.

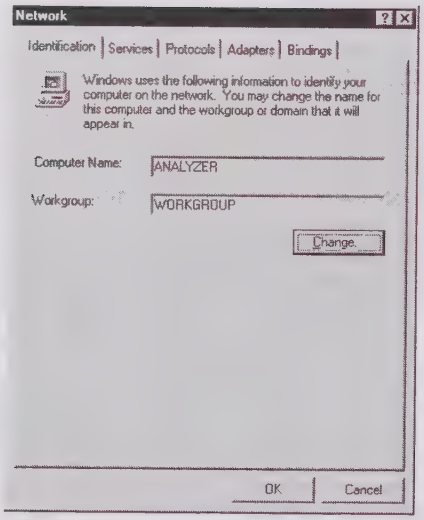
The instrument carries out a restart.

The installation of the network card driver is thus completed. Next, the FS-K3 software must be installed (see chapter "Installation of FS-K3 on FSP").

Installation of the network driver for instruments with the LAN interface option

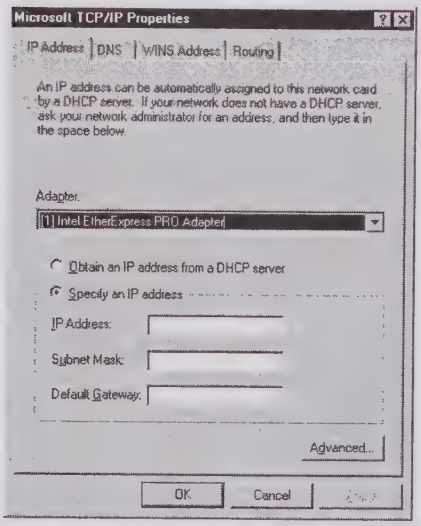
If the FSP-B16 option is built into the instrument, the basic condition for operating the FS-K3 is already effective. What remains to do is to ensure that the TCP/IP protocol has a correct configuration:

- Open the start menu of Windows NT with the key combination <**CTRL**>-<**ESC**> .
- Select menu items **SETTINGS – CONTROL PANEL – NETWORK.**



- Select the tag "Protocols".

The "Network Setup Wizard" appears.


Microsoft TCP/IP Properties
IP Address
DNS
WINS Address
Routing
An IP address can be automatically assigned to this network card by a DHCP server. If your network does not have a DHCP server, ask your network administrator for an address, and then type it in the space below.
Adapter:
[1] Intel EtherExpress PRO Adapter
Obtain an IP address from a DHCP server
Specify an IP address
IP Address:
Subnet Mask:
Default Gateway:
Advanced...
OK
Cancel

- Leave the selection "Adapter" unchanged.
- Click "Specify an IP address".
- Enter the IP Address and Subnet Mask assigned to the instrument. This address is given by the network administrator.
- Leave dialog with OK.

Installation of FS-K3 on FSP

- Insert the program diskette in drive A.
- Open the Windows NT start menu with <CTRL><ESC> and select "RUN".
- Enter the command "A:SETUP" and terminate it with <ENTER> or by clicking "OK".
  The installation program of the FS-K3 is started and takes you through the subsequent installation.
- Follow the installation instructions on the screen.
- After the installation is completed, close the FS-K3 program group with <ALT><F4>.
- Open the Windows NT Explorer (via the start menu, see above) and copy the files D:\R_S\INSTR\RSIB\RSIB.DLL and D:\R_S\INSTR\RSIB\RSIB32.DLL into the directory C:\WINNT\SYSTEM32.
- Close the Windows NT Explorer with <ALT><F4>.

Starting FS-K3

- Open the Windows NT start menu with <CTRL><ESC>.
- Start FS-K3 by selecting the sequence PROGRAMS – FS-K3 – FS-K3 with the cursor or mouse (terminate entry with <ENTER> when using the cursor keys).

  Note:
  Other programs of the FS-K3 packets (FS-ENR, FS-Noise) are started analogously to the start of FS-K3 via the Windows NT start menu.
- FS-K3 is started and its window is opened.
- When starting the program for the first time, a code has to be entered. The code is supplied with the instrument.
- This code is not necessary later on and the program then announces itself with the main menu.
- Set the selection switch to *DDE* in the *Device* menu of the FS-K3 (see chapter 4, Device Setting)

Switchover of screen between FS-K3 and analyzer

- Press the key combination <ALT><TAB>, if necessary several times, to select "R&S Analyzer Interface" or "FS-K3"

Closing FS-K3

- Select the **Exit** command from the **File** menu or press the key combination **<ALT><F4>.**

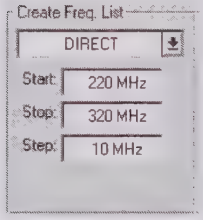
Before the program is shut down, you are given the opportunity to save all settings including test results. If you would like to save, click the button Yes.
All data will be available on the next call-up of FS-K3 and you will be able to carry out measurements immediately. Software FS-K3 is thus closed down.

2 Quick Start

In order to quickly familiarize yourself with the FS-K3 software, this chapter will lead you step by step through an ordinary measurement. The gain and the noise figure of an amplifier are to be determined in the range from 220 MHz to 320 MHz.

Program Settings

- Start the FS-K3.
- Enter the desired frequency range in the main menu in the field **Create Freq. List**. In our example, 220 MHz are entered for **Start** and 320 for **Stop**. The input field accepts m or M as a shortcut for MHz.



- Enter the desired step size in the **Step** field. In our example, 10 MHz should be entered. Thus, a measurement is taken at 11 frequency points. The number of steps can be expanded to up to 100 frequency points. Of course, this would result in an accordingly long measuring time.
- Open the input window for ENR values (menu item **ENR**) and enter the ENR value of your noise source.

The default of the ENR value is 15.00 dB. The ENR value can be entered as a common value (**ENR All**) with a range that is valid for all frequencies or frequency-dependent in tabular form. For this purpose, several ENR sampling values must be entered at various frequencies. These sampling values are supplied by the manufacturer of the noise source. To facilitate the introduction, it is sufficient to specify a common ENR value for this measurement.

- Enter the ENR value that is valid for the range 220 MHz to 320 MHz in the field **ENR All**. This value is only active if the option switch for **ENR All** is active. This is already the case in the default setting.
- Close the window with OK.

➢ Open the window for device settings (menu item **Device**). If your analyzer is equipped with an internal computer function and you use this function for operation of the FS-K3, the correct interface setting will be **DDE**. This is also the default setting of the software. The default selection for the analyzer is " FSEX ". This selection covers the complete model series of the FSE family (e.g.: FSEA20, FSEA30, FSEK..etc.). Make sure that the two files RSIB.DLL and RSDDE.DLL are in the right directory (see chapter 1, Setting up and Starting the FS-K3).

If, however, an external computer is used, the IEC BUS interface will be used for control. To this end, a switchover from DDE to GPIB is required. Besides, the address of the analyzer is to be set using the select arrow. Make sure that a Windows-compatible IEC BUS card has been installed correctly.

Performing the Calibration

➢ Connect your noise source to the RF input of the analyzer.
(see Fig. 2-1)

➢ Connect the supplied lowpass filter to the voltage supply input of your noise source.

➢ Ensure the voltage supply of your noise source by connecting it to the +28-V socket (NOISE SOURCE at rear of instrument) of the analyzer via a coax cable. The lowpass is connected between the noise source and the NOISE-SOURCE socket of the analyzer. The purpose of the lowpass is to suppress any interference (e.g. due to RF interference), including interference via the supply line. Thus, very precise measurements are possible.

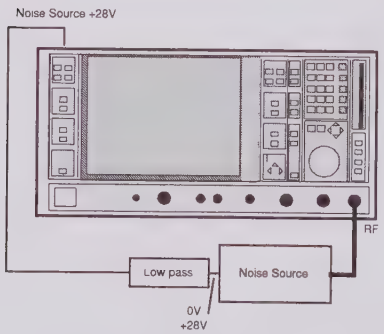


Fig. 2-1 Preparation for calibration

➢ Start the calibration using CAL.
During the calibration, the text: "*Calibration Running ESC to Stop*" appears in red color. The yellow output fields permit to observe the progress of calibration. After it has been terminated, the red text will disappear again. After a successful calibration, the display **done** in the **Calibration** field will change its color from white to green. However, if there are error messages, check the settings DDE/GPIB in the menu item **Device** or the installation of the GPIS drivers.

Amplifier Measurement

➢ After successful termination of the calibration, the DUT is inserted into the test setup. (see Fig. 2-2)

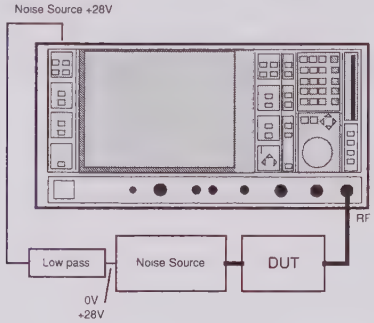


Fig. 2-2: Test setup

➢ Start the measurement using RUN.
During the measurement, the text *Measurement Running ESC to Stop* will appear in red color. The yellow output fields permit to observe the current measured values. Besides, the results are shown graphically with the measurement in progress. The current measured values are displayed graphically with thick lines. As the scaling of the graph is automatically adapted to the measurement results in the default setting, the vertical axes of the graphical display may be repeatedly rescaled during the measurement. After the measurement has been completed, the red text disappears and the graph is built up again with thin lines.

3 General Operating Instructions

- **Changing the input focus:**
  This is possible in the usual way by mouse clicking. It is also possible to reach the desired input field by pressing the TAB key several times. The key combination Shift+TAB resets the input focus by one field.
- **Closing windows:**
  A window is closed by clicking on the OK button. When using a keyboard, the key combination Alt+F4 can be used instead. Closing of the main menu terminates the FS-K3 software.
- **Entering numerical values:**
  Numerical values are entered as usually under Windows. Irrespective of the country setting, only the point "." is accepted as decimal separator. A comma "," will be ignored. Spaces are also ignored.

Table 3-1 Special meaning of individual keys for numerical entry

Entry:	Meaning:
k or K	Kilo
m or M	Mega
g or G	Giga
e, E, d or D	Exponent
h,b, etc.	Separator, the following characters are ignored. This is very useful, since what is left over of old values does not have to be deleted.

Table 3-2 Examples of entered frequencies

Entry:	Result:	Remark
100000	100 kHz	
100.2k	100.2 kHz	
100.2 k	100.2 kHz	
100.2 K	100.2 kHz	
100.2m	100.2 MHz	
100.2M	100.2 MHz	
24.2g	24.2 GHz	
24.2G	24.2 GHz	
10e6 4552	0 Hz	faulty entry
1e6	1 MHz	
10e6H 3423	10 MHz	H used as separator
10d4	100 kHz	

The entry is confirmed by means of Return.

After confirmation of the entry, the entered value is immediately checked by the program. The entered value is reformatted and immediately returned into the input field. Thus, the user can see at once how the entry has been interpreted by the program.

Caution: *Quitting an input field is identical with a confirmation or* ***Return****.*
If the ***ESC*** *key is pressed instead of* ***Return****, the initial value will appear again in the input field.*

- **Opening windows using shortcuts**
  In the main menu, the windows can be opened using the key combination Alt + <underscored menu letter>.

  Example: main menu **Alt+e** Opening the window **ENR** for ENR input
  Alt+d Opening the window **Device**
  Alt+o Opening the window **LOSS**

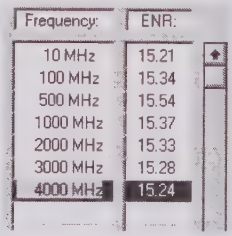
- **Changing a setting**

The setting can be changed by directly clicking on it. However, the keyboard can also be used for this purpose. To this end, first activate the field using the TAB key. Then make your change using the cursor keys ↑ and ↓.

- **Activating an option**

The easiest way to activate an option is by means of a mouse click. In order to use the keyboard, activate the field using the TAB key first. Then the option can be switched on or off by means of **Return** or **Space**.

- **Entering tabular values:**



The entry is possible by clicking on the fields and entering the value pairs. The current line is marked in blue. The table must not contain any blank lines between the value pairs (except for limit line).

Helpful commands if only the keyboard is used for the entry:

TAB	The focus moves one field to the right
Shift+TAB	The focus moves one field to the left
Cursor ↑	The focus moves one line up
Cursor ↓	The focus moves one line down

If the focus is moved out of the respective input field, this corresponds to a confirmation or pressing of the RETURN key.

Up to 100 value pairs can be entered. In the case of more than 15 value pairs, the table must be scrolled by means of the scroll bar, which can be operated using the mouse. However, it is also possible to activate the scroll bar using the TAB key and then move it using UP and DOWN.

4 Function Description of the Individual Windows

Main Menu

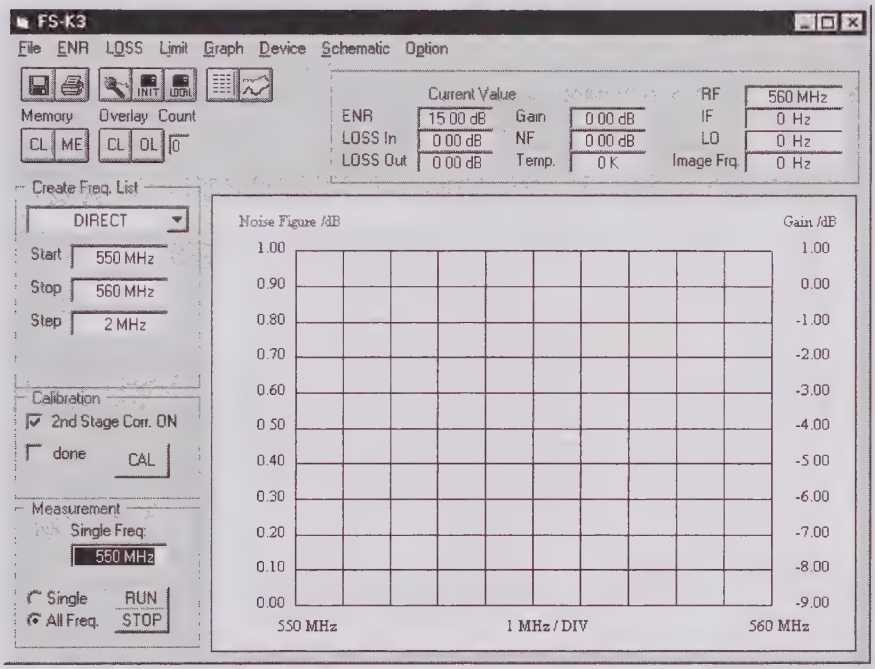
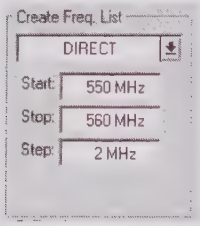


Fig. 4-1 Main menu

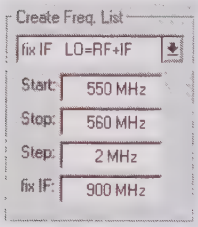
Create Freq List

The *Create Freq List* area is used for entering the start, stop and step frequency. These frequency entries always refer to the input frequency. This is also true for frequency-converting measurements. The select field permits to set one of five modes. Each time a change is made in the input fields of the *Create Freq List* area, the calculation of a complete frequency list is started. This internal list contains the values for ENR, LOSS, LO frequency etc. for each test frequency. These frequencies are used as sampling points in the subsequent measurement. The list can be displayed on the screen using the menu item **Option / Edit Freq List**.

Description of the 5 different settings in the select field:



DIRECT
This mode is required for DUTs without frequency conversion (e.g. amplifiers).



fix IF LO=RF+IF
This setting is used for measurements on frequency-converting DUTs with a fixed intermediate frequency (e.g. mixer).

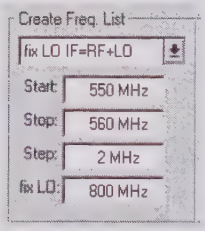
If this setting is selected, an additional input field will appear, where the desired intermediate frequency (IF) is to be entered.
The program controls an external signal generator for generation of the LO signal. The generator must be remote-controllable via IEC BUS. The following is true for the LO frequency:

$f_{LO} = f_{RF} + f_{IF}$

The program calculates a frequency table that can be called up via the menu item Option / Edit Freq List.
The hardware settings for the external generator are defined in the Device window. Instead of an external generator, a voltage source can also be driven, which controls a VCO. This VCO will then generate the LO signal. For more details see under Option / Edit Freq List

fix IF LO=abs(RF–IF)
This setting only differs in the formula for calculating the LO frequency:

f_{LO} = absolute ($f_{RF} - f_{IF}$)



fix LO IF=RF+LO
This setting is used for measurements on frequency-converting DUTs with a fixed LO frequency, e.g. satellite converters with a fixed LO frequency.
If this setting is selected, an additional input field will appear, where the LO frequency is to be entered.
The following applies to the intermediate frequency:

$f_{IF} = f_{RF} + f_{LO}$

fix LO IF=abs(RF–LO)
This setting only differs in the formula for calculating the intermediate frequency (IF):

f_{IF} = absolute ($f_{RF} - f_{LO}$)

Each time a change is made in the field *Create Freq List,* the frequency list will be recalculated. This may last for a few seconds. Besides, all the changes that have been made manually in the window **Option / Edit Freq List** are overwritten.

Image Rejection

This window only appears after selection of a frequency-converting mode in the field *Create Freq List*. The image rejection of the converting DUT can be entered here. This entry applies to the complete frequency range. The default value is 999 dB. This means that the second sideband is taken into account in the calculation with a suppression of 999 dB. Thus, it does not noticeably affect the measurement result. An entry of 0 dB means that both sidebands are converted to the same extent. The setting 999 dB corresponds to the generally used single-sideband measurement.

In the case of a single-sideband mixer (SSB = single sideband) with a high image rejection, the setting 999 dB leads to correct results.

If the value 999 dB is entered for measurements on a mixer without image rejection (DSB = double sideband, i.e. both sidebands are converted to the same extent), the following error in measurement will be produced:

The actual noise figure is 3 dB higher and the gain 3 dB lower than the measured value displayed.

If the entered value is changed to the actual image rejection (here: 0 dB), noise figure and gain will be correctly displayed.

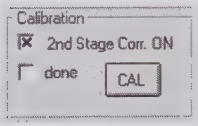
By entering the image rejection, the correct measurement results are always obtained. It covers the measurement modes SSB, DSB and all values in-between for the image rejection.

Setting for SSB: 999 dB
Setting for DSB: 0 dB

In most cases, the gain can also be determined using other measurement procedures. By comparing the results, the measurement accuracy can be checked using the FS-K3.

For the comparison with noise test systems of other manufacturers, it is recommended to enter 999 dB (corresponds to SSB) in the *Image Reject* field. This is the setting implicitly used by almost all manufacturers (for more details see chapter 5).

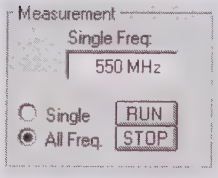
Calibration, 2nd Stage Correction ON:



This field permits to switch the Option *2nd Stage Correction* on or off. With the *2nd Stage Correction* switched on, the program expects a calibration of the test setup. This calibration is started using *CAL*. During the calibration, the text *Measurement running Press ESC to Stop* appears in red. It disappears after the calibration has been terminated. A valid calibration is indicated by the field *done* in green color.

If the focus is changed from the *CAL* field to a different field during the calibration (e.g. by pressing the TAB key), the calibration will be aborted. Pressing of the ESC key has the same effect.
If the option *2nd Stage Correction* is not activated, no calibration will be possible. The option can be switched on and off without a valid calibration being lost. (For more details see chapter 5 Noise Measurement).

Measurement



By activating the RUN field a measurement is started.
If *All Freq.* is marked in the select field, the complete frequency list will be executed. During the measurement, the text *Measurement Running ESC to Stop.* is shown in red. After termination of the measurement, this text disappears. If the focus is changed from the *RUN* field to a different field during the measurement (e.g. by pressing the TAB key), the measurement will be aborted. Pressing the ESC key or activating the STOP field has the same effect.

If the *Single* field is marked, the measurement is made at one frequency point only. The test frequency is set in the *Single Freq* field. This frequency does not need to be included in the frequency list. The program interpolates all the values and calibration data. In SINGLE mode, a continuous measurement is made until it is aborted by means of ESC or STOP. The current measurement results appear in the *Current Value* field.

Note: *The frequency entry in the field* Single Freq *will be overwritten if a frequency has been selected in List mode.*

(See chapter 4, Graphic / List Switchover *)*

Menu File

Save Setting:

Menu item: **File / Save Setting**
This menu item opens an input window for the name of the file in which the settings are to be saved. The file name must end with ".K3". All settings and data (test data, memory data and calibration data) are stored. The program can be quit and restarted. After loading the data, a measurement is immediately possible again. If the file name "INIT.K3" is selected, the program immediately starts with these settings. When the program is quit, a decision can be made about whether the initialization file "INIT.K3" is to be updated with the last settings. These will be immediately loaded when the program is started again.

Load Setting:

Menu item: **File / Load Setting**
This menu item opens an input window for the name of the file containing the settings. The file name must end with ".K3". All settings and data are loaded. (see chapter 4, Save Setting)

Load Default:

Menu item: **File / Load Default**
This menu item overwrites all the settings with the default settings of the program. This may be useful if a wrong or corrupt "INIT.K3" file has been loaded. This function permits to easily restore the default settings and the original "INIT.K3" file.

Print:

Menu item: **File / Print**
This menu item opens a window that shows a preview of the printout. Individual parts of this comment can be blanked in this preview. Comments can be edited in the menu item **Option / Report**.

The font used for printing is purely graphical. Windows NT tries to change this font into a known font type. In most cases, this causes the font to be shifted. To avoid this, this conversion should be switched off in the printer setting under Windows NT.

Some printer drivers find it difficult to convert colors into shades of gray. In cases like this, it is recommended to switch off the Option *Color ON*.

Creating the preview requires considerable computing power, which is why there may be a short delay between calling up and output of the preview.

Export WMF:

Menu item: **File / Export WMF**
This menu item is used for exporting graphics files. This function permits to store graphs or lists as graphics files. It opens a window where a preview of the metafile can be seen. In this preview, individual parts of the comment can be blanked. Comments can be edited in the menu item **Option / Report**.

The font used for printing is purely graphical. This is also the case in list mode. For storage, the metafile format (*.wmf) is used.

When reading in and printing, some word processing programs find it difficult to convert colors into shades of gray. In this case, it is recommended to switch off the Option *Color On* in the *Print* window.

Creating the preview requires considerable computing power, which is why there may be a short delay between calling up the preview with: *File / Export WMF* and its display.

The metafile can be saved by clicking on the SAVE field. Then, an input window is opened for entering the name of the file in which the graph is to be stored. The file name must end with ".WMF". In list mode, one page may not be sufficient for the output. In this case, the user will be requested to enter a file name for the second page.

Note: *The file names print1.wmf and print2.wmf are not permissible, since these files are already used by the FS-K3. Should there be problems with the font size when saving in list mode, your computer does not have enough available memory space.*

*Under Windows, the key combination **Alt + Print** can be used to copy the contents of the current window into the clipboard. From there, the output can be embedded in other programs.*

Export DAT:

Menu item: **File / Export DAT**
This menu item permits to store measured data in a format that can be read by other programs. Thus, it is e.g. possible for EXCEL to read and further process the data items. The point "." serves as decimal separator, the comma "," separates the individual data items. When reading in data in EXCEL make sure that the corresponding settings have been made in the import filter of EXCEL. It may be necessary to change the country setting from the comma to the point of the decimal separator. The file structure is described in chapter 7.

Export TXT:

Menu item: **File / Export TXT**
This menu item permits to store measured data in the ASCII format. This format can be read by any word processing program. Thus, the measurement results can be embedded and further processed in any text. The file structure is described in chapter 7.

Exit:

Menu item **File / Exit**
This menu item terminates the program. Alternatively, the program can also be quit using the key combination *Alt + F4*. Before it is closed, the user is prompted to decide whether the initialization file (INIT.K3) is to be updated. The initialization file for the ENR table (INIT.ENR) is also updated. When calling up the program again, the last valid settings and data will thus immediately appear. It is always possible to restore the default setting and also the default of the initialization file "INIT.K3" using the menu item **File / Load Default**.

Menu Graph

Graphic / List switchover:

Menu item: **Graph / Mode**

These two fields permit to select between graphical output or output in the form of a list. This also has an effect on the commands **File / Print** and **File / Export WMF**. The output is made according to the selected type of display.

The output in list mode enables frequency selection by means of a mouse click. This frequency selection is valid for the *Single* setting (see Measurement) and for the Search function. If a frequency is to be selected, just click on it. The selected frequency is marked in blue. The selection of a frequency in list mode overwrites the entry in the field *Single Freq* (Fig. 4-2). To reactivate the *Single Freq* field, the blue bar must be shifted onto the first frequency in the list field (Fig. 4-3).

Frequency	Gain	NF	Temp.
550 MHz	0.00 dB	0.00 dB	0 K
552 MHz	0.00 dB	0.00 dB	0 K
554 MHz	0.00 dB	0.00 dB	0 K
556 MHz	0.00 dB	0.00 dB	0 K
558 MHz	0.00 dB	0.00 dB	0 K
560 MHz	0.00 dB	0.00 dB	0 K

Fig. 4-2 Selection of test frequency 552 MHz for measurement in Single Freq mode

Frequency	Gain	NF	Temp.
550 MHz	0.00 dB	0.00 dB	0 K
552 MHz	0.00 dB	0.00 dB	0 K
554 MHz	0.00 dB	0.00 dB	0 K
556 MHz	0.00 dB	0.00 dB	0 K
558 MHz	0.00 dB	0.00 dB	0 K
560 MHz	0.00 dB	0.00 dB	0 K

Fig. 4-3 Test frequency in Single Freq mode is taken from the respective input field

Menu Device

Initialization of the spectrum analyzer:

Menu item: **Device / Init**

This function is always required if analyzer settings have been changed manually or the analyzer has been switched off in the meantime. The INIT field triggers a PRESET on the analyzer and subsequently executes the settings defined in the program.

Local:

Menu item: **Device / Local**

This function causes the analyzer to be reset from the remote to the local state. After this function has been called up, the analyzer can again be manually operated. Of course, the Local key of the analyzer can also be used to set the local state. In this case, however, the program does not receive any information on possible changes in the analyzer settings. Thus, it cannot inform the user on the necessity of an initialization.

Search function

This function enables the detailed investigation of possible faulty measurements due to unwanted RF interference. One of the most frequent causes of faulty measurements is interference received by the DUT. The spectrum analyzer permits to search for this interference specifically.
As a noise test set, the spectrum analyzer usually operates in the ZERO SPAN mode with a large bandwidth (RBW: 1 MHz). If a measurement result occurs which suggests RF interference, the analyzer can be easily switched over using this search function. The SPAN is switched over from 0 Hz (ZERO) to 5 MHz and the bandwidth reduced to 10 kHz. Thus, the measured value in question can be examined in greater detail. It is now up to the user to check the measurement for interference by varying the CENTER FREQUENCY, SPAN and RBW. By pressing the LOCAL key, the analyzer can be manually operated. There must not be any interference in a frequency range that corresponds to at least twice the noise test bandwidth.

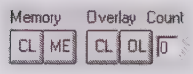
To obtain an output with the measurement made only at points without interference, it is recommended to cross off these points from the frequency list or change the frequency manually. This is possible in the menu **Option / Edit Freq List.**

The search function sets the CENTER FREQUENCY to the value set in the *Single Freq*: field. The frequency entry in the *Single Freq*: field will, however, be overwritten if a frequency is selected in the list mode. Thus, fast checking is possible by simply clicking on the frequency points (see chapter 4, Graphic / List Switchover).

If the computer function of the analyzer is used, the screen display must be switched over to analyzer mode using the key combination *Alt + Print* after calling up the search function. Switchover to the Windows surface is also possible again using the key combination Alt + Print.

After the search for spurious has been terminated, the analyzer must be initialized again using the function . Then the spectrum analyzer is again ready for the noise measurement.

Memory, Overlay



The program offers two independent ways of saving measured values, which can be displayed in the graphics output.

The *ME* field loads the current measured values into an additional memory and outputs them in the graphics on the screen. The representation of these data items in the graphics output is determined in the **Graph** menu. Data written into this memory are saved using the function **File** / **Save Setting**. The first click on field CL clears memory and the second click clears data.
The menu **Graph** / **Memory** permits to blank the stored trace without deleting it.

The second way of simultaneously displaying several curves is provided by the *Overlay* function. With each clicking on the *OL* field, the current measured values are transferred to the overlay memory. This always increments the display in the *Count* field. All values in the overlay memory are always displayed simultaneously. Thus it is possible to simultaneously show a number of traces on the screen. This method is recommended in order to graphically compare and document the effects of small changes on the DUT. The display of the overlay data in the graphics output is set in the menu item **Graph**. The *CL* field clears all overlay data and resets the counter in the *Count* field to zero.

Both types of saving and displaying several traces are independent of each other. They can be used individually or together. However, there are more graphical display possibilities for the *Memory* function. The *Memory* function permits to store only one additional data set. The *Overlay* function can store up to five additional data sets. In contrast to the memory data, the overlay data are *not* stored using the function **File** / **Save Setting**. They are lost after terminating the program.

Current Value

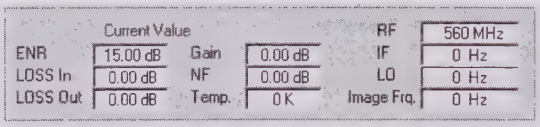


Fig. 4-4 Current Value

This area shows the current values of the ongoing measurement. The progress of a measurement can be observed here. The user is thus given the possibility of checking the entered values for *ENR* and *LOSS*. The display of the ENR values always refers to the input frequency RF. The ENR values of the intermediate frequency with a converting measurement are not displayed. The values for *LOSS In* refer to the receive frequency (RF), the values for *LOSS Out* to the intermediate frequency (IF). With the direct measurement, the two values apply to the receive frequency (RF). The field *Image Frq* indicates the image frequency for the converting measurement. It is not required for the calculations. It only serves as information to the user and to indicate possible spurious responses (see chapter Noise Measurement SSB and DSB).

The *Temp* field shows the equivalent noise temperature of the DUT. This value is directly derived from the noise figure (*Noise Fig*).

Edit ENR Table (Menu item ENR Shortcut: Alt+e)

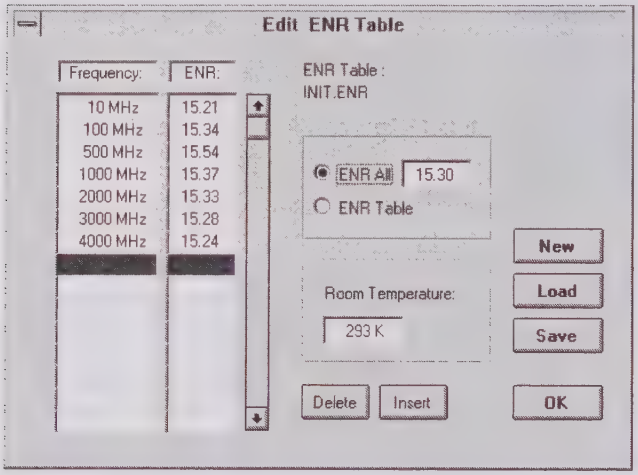


Fig. 4-5

It is absolutely necessary to report the noise factor (= ENR values) of the noise source to the program. The ENR values are supplied with the noise source.

Select Window ENR All

The ENR values of the noise source can be reported to the program in two different ways. According to the position of the selector switch, one of the two possibilities is active.

- *ENR All*
  Only one value is indicated, which is used for the complete frequency range. This value is entered in the field *ENR All* and the selector switch is set to *ENR All* accordingly. The values in the table are ignored.
- *ENR Table*
  The value pairs in the table are taken into account. Values in-between are automatically interpolated by the program. The value in the *ENR All* field is insignificant in this setting.

Entry of a Table for ENR Values

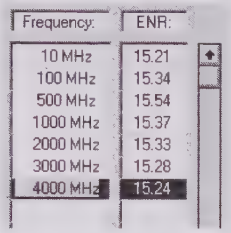


Fig. 4-6 Table of the ENR values

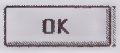
The entry is made by clicking on the fields and entering the value pairs. The current line is marked in blue (see also chapter 3). The table must not contain any blank lines between the value pairs.

After entering the table set the selector switch to *ENR Table*, since otherwise the values of the table will be ignored and the value in the field *ENR All* used.

Clears an existing table and changes the table name into INIT.ENR

Saves the created ENR table.

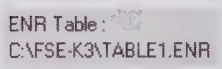
Loads a previously created ENR table.



Closes the window. As an alternative, the key combination *Alt + F4* can also be used.

Clears the line marked in blue from the table.

Inserts an additional blank line ahead of the line marked in blue.



This field shows the name of the ENR file that has been loaded or saved.

The current room temperature can be entered here. It is taken into account in the calculation of the noise figure.

Edit LOSS Table (Menu item: LOSS Shortcut: Alt + o)

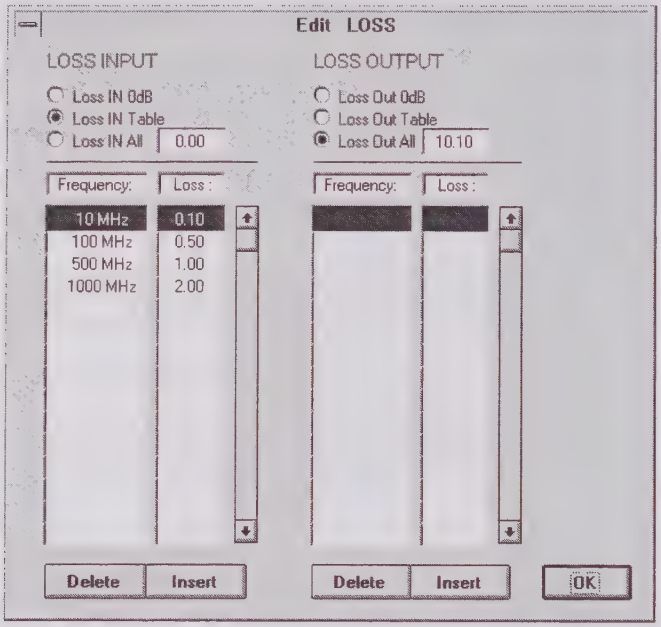


Fig. 4-6 Menu Edit LOSS

The entry of the LOSS values permits to also consider additional losses due to cables or attenuators that are not taken into account in the calibration. It is possible to enter:

- the additional loss between noise source and DUT (LOSS INPUT)
- the additional loss between DUT and analyzer (LOSS OUTPUT).

Select Window

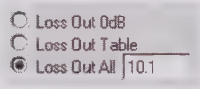


Fig. 4-7 Select window

The losses can be entered in three ways, for *LOSS INPUT* and *LOSS OUTPUT* separately. To this end, three positions are provided for the selector switch of the losses:

- *Loss In 0 dB* or *Loss Out 0 dB* (= Default setting)

  Caution: *No additional losses are taken into account.*

- *Loss In Table* or *Loss Out Table*
  The frequency-dependent value pairs in the respective LOSS table are taken into account. Values in-between are automatically interpolated by the program.

- *Loss In All* or *Loss Out All*
  The value in the field *Loss In All* or *Loss Out All* is also used for the calculation. This value is assumed to be frequency-independent.

Entry of the LOSS Values in Tabular Form

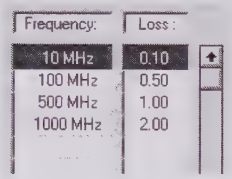


Fig. 4-8 LOSS value table

The entry is made by clicking on the fields and entering the value pairs. The current line is marked in blue (see also chapter 3). The table must not contain any blank lines between the value pairs. Up to 100 value pairs can be entered.

Note: *After entering the table set the selector switch to the position Loss In Table or Loss Out Table, since otherwise the values of the table will be ignored.*

Delete Deletes the blue line from the table.

Insert Inserts an additional blank line at the line marked in blue.

OK Closes the window. Alternatively, the key combination *Alt + F4* can also be used.

Edit Limit Line (Menu Item: Limit Shortcut: Alt + i)

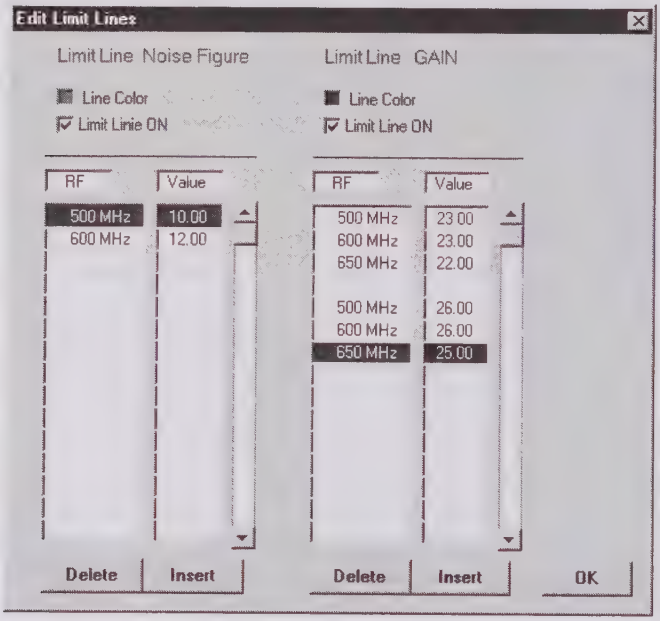


Fig. 4-9 Menu Edit Limit Line

Entry of a Table for the Sampling Values of a Limit Line

Fig. 4-10 Table for the sampling values of a limit line

The entry is made by clicking on the fields and entering the value pairs. The current line is marked in blue (see also chapter 6). The value pairs for any polygonal curve are indicated. It is also possible to simultaneously represent several limit lines, separated from each other by a blank line. Thus it is very easily possible to represent minimum and maximum lines at the same time. If the table contains several blank lines, the values after these blank lines are not taken into account any more.

The two input windows for value pairs permit to enter separate limit lines for noise figure and gain. In order for the entered values to be displayed, the field *Limit Linie ON* must be activated.

Limit Linie ON — All limit lines included in a table are displayed or blanked via a mouse click.

OK — Closes the window. Alternatively, the key combination *Alt + F4* can be used. By closing the window, the limit lines in the output graph are also updated.

Delete

Deletes the line marked in blue from the table.

Insert

Inserts an additional blank line ahead of the line marked in blue.

Line Color

By clicking on the colored field, the following color selection window is opened:

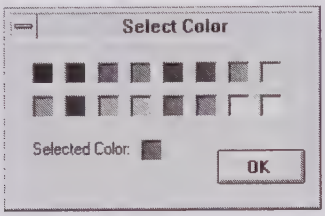


Fig. 4-11 Color selection window

By clicking on the individual color fields, a particular color can be assigned to the limit lines.

Graphic Settings (Menu Item: Graph Shortcut: Alt + g)

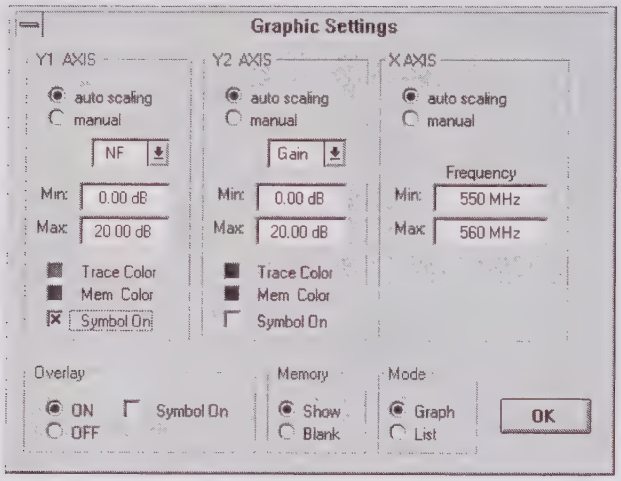


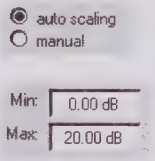
Fig. 4-12 Menu for setting the graphics

Y1 AXIS This axis is located on the left side of the graph. Depending on the setting, it scales the noise figure or the equivalent noise temperature of the DUT.

Y2 AXIS This axis is located on the right side of the graph. It scales the gain of the DUT.

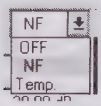
X AXIS This axis is located at the bottom of the graph. It scales the frequency range. The input frequency range (RF) is always displayed. The intermediate frequencies (IF) cannot be displayed.

Scaling of the Axes



The individual axes can be scaled automatically or manually. The algorithm for automatic scaling intentionally permits only certain integral grid settings. Besides, extreme values due to faulty measurements are not taken into account. Thus, the display of the graph makes sense in almost all cases. Furthermore, a manual setting is possible (fields *Min* and *Max*).

Selection of the Display



The selection list permits to show or blank individual graphs. For the left y-axis (y1 AXIS), it is also possible to select between noise figure and noise temperature.

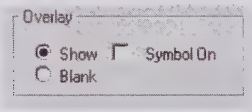
Color Selection of the Graphs

Fig. 4-13 Color selection of the graphs

By clicking on the colored field, the following color selection window is opened:

By clicking on the individual color fields, the colors of the current traces as well as of the stored trace can be determined individually. The colors for the trace display in the *Overlay* mode cannot be determined individually.

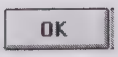
When this option is activated, each measured value in the graph is marked by a symbol. This setting makes sense if several traces are to be simultaneously output on a monochrome printer and no color assignment is possible.



In this field, traces stored in overlay mode can be shown or blanked. The stored traces are bit deleted by blanking.

In this field, traces stored in memory mode can be shown or blanked.

This field permits to select Graph/List in the display mode. This function corresponds to the Graphic / List switchover ( ) in the main menu.



Closes the window. Alternatively, the key combination *Alt + F4* can be used. Closing of the window also updates the output graphics.

Device Settings (Menu Item: Device Shortcut: Alt + d)

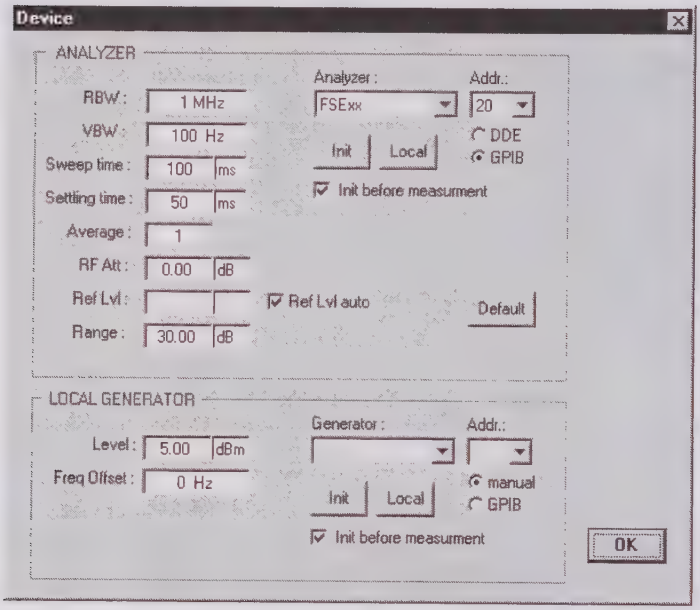


Fig. 4-14 Menu Device

This window permits to perform the device settings for the analyzer or for the signal generator to be used for generation of the LO signal.

ANALYZER Area

RBW: 1 MHz

Entry of the resolution bandwidth (RBW) of the analyzer. The resolution bandwidth should be selected as large as possible. This considerably improves averaging of the display. Besides, a high noise display reduces the influence of external interference sources.

For measurements at low frequencies, the resolution bandwidth must be reduced in order for the measurement not to be invalidated by the LO oscillator of the analyzer. At receive frequencies of 100 kHz, the selected bandwidth must not exceed 10 kHz.

VBW: 100 Hz

Entry of the video bandwidth (VBW) of the analyzer. The video filter is used to smooth the noise signal. It should be set as narrowband as possible. The 1-Hz setting causes long wait times. However, it may be necessary if the resolution bandwidth (RBW) has been reduced very much.

Sweep time: 100 ms

Entry of the sweep time of the analyzer. It must be increased with narrow bandwidths in order to obtain stable measurement results.

This field permits to enter the wait time required for settling of the DUT. Most noise sources generate an interfering DC component in addition to the noise spectrum. When the noise source is switched on and off, low-frequency DUTs may require a certain wait time until the DUT has settled. During this wait time, coupling capacitors are charged or discharged.

This field permits to enter the number of sweeps over which the average is taken with each measurement. A higher number implies a more stable display, but also longer measuring times. In most cases, one sweep is sufficient (Average 1).

Entry of attenuator position (RF ATT) of the analyzer. For a low noise figure of the analyzer, 0 dB should be set. With high levels or critical matching, a higher setting is also possible.

Setting of the reference level (Ref Lvl) of the analyzer. The following cases are to be distinguished:

- Ref Lvl auto active
  2nd stage Corr ON active
  Prior to each calibration, several test measurements are performed at the very first frequency test point. An appropriate reference level is then determined and set. A maximum gain of the DUT is taken into account, which is to be entered in the *Range* field.

- Ref Lvl auto active
  2nd stage Corr ON not active
  Prior to each measurement, several test measurements are performed at the very first frequency test point. Then an appropriate reference level is determined and set. The entry in the *Range* field is insignificant.

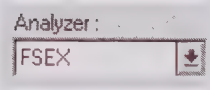
- Ref Lvl auto not active
  The reference level is manually set. It should be about 5 dB to 15 dB above the noise display that occurs with the DUT connected and the noise source activated.
  Since no test measurements are performed with this setting, the total measuring time is reduced.
  Even in the case of DUTs with a high-ripple frequency response, it is useful to enter the reference level manually, as an automatic reference level setting might not always lead to optimal settings.

This field permits to enter the maximum gain of the DUT to be expected. This value is taken into account in the automatic reference level determination if the following settings have been made:

- Ref Lvl auto active
  2nd stage Corr ON active

The entry in the *Range* field must not exceed the value 60. Furthermore, this value should not exceed the actual gain of the DUT. A reserve of 10 dB is sufficient. This makes sure that the measurements are always performed in an optimal operating range of the analyzer.

This option causes an initialization of the analyzer prior to each calibration and measurement cycle. This ensures that any manual change in the analyzer settings is reset. To reduce the measuring time, it is recommended to switch off this option.



Selection of the analyzer.
The setting FSEX can be used for the whole FSE family (FSEA20, FSEA30, FSEB30 etc.). If the analyzer is equipped with a preselection or switchable preamplifiers, a different type can be selected in order to utilize these features.

Setting the type of interface to be used for controlling the analyzer.

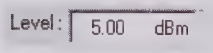
DDE
This setting is selected if the analyzer is equipped with a computer option (FSE-B15), which is also used. The analyzer is then controlled via the internal software interface. This interface can only be used if the two files RSDDE.DLL and RSIB.DLL are present in the correct directory (see chapter 1). The address need not be entered.

GPIB
This setting is selected if the analyzer is controlled via an external computer. The control is then performed via the IEC-BUS (GPIB) interface. In this case, make sure that the set address complies with the analyzer address.

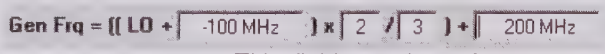
These two fields in the *ANALYZER* area correspond the two fields (see chapter 4).

By clicking on this field, the *ANALYZER* settings are reset to their default.

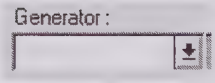
LOCAL GENERATOR Area



This field permits to enter the desired output level of the external generator. The setting takes effect after initialization of the generator (clicking on the *Init* field).



This field permits a frequency offset and a multiplier for the generator to be entered. It is added to the LO frequency proper in the transmission.



Select field of the generator
The GPIB commands of the individual devices are listed in the file LO_K3.GEN. This device list can be supplemented at any time (see chapter 7).

Setting of the GPIB address of the generator and switchover between manual operation and GPIB control of the generator. The *manual* setting only makes sense in the *fix LO* mode. All generator settings are to be performed manually in this case. If manual is also selected in the *fix IF* mode, useless measurement results are produced, as the program expects the generator to be also automatically tuned with the test frequency. In the *fix IF* mode, the *GPIB* setting is therefore absolutely necessary so that the program can tune the generator frequency respectively.

By clicking on the Init field, the initialization sequence is transferred to the generator. This sequence is defined in the file LO_K3.GEN (see chapter 7 List of Files; LO_K3.GEN).

Closes the window. Alternatively, the key combination *Alt + F4* can be used. Closing of the window does not yet cause the setting data to be transferred to the analyzer or generator. This is only done with the next initialization.

Caution: *The Software FS-K3 does not check to which extent the specified settings can also be performed by the analyzer. Violations of the frequency range of the analyzer or generator are not signaled, neither are violations with other settings (RBW, VBW, RF ATT, etc.).*

Test Setup (Menu Item: Schematic Shortcut: Alt + s)

The display in the window *Schematic* distinguishes between two different types. Depending on the mode set (*Direct Measurement* or *Frequency Converting Device*) the respective test setup is indicated.

The Schematic window only serves to provide information on the test setup and frequency ranges. The values in the *Schematic* window are updated each time the frequency ranges are changed. The window may remain open while the frequency settings are performed in the main menu. Thus, the user can immediately check his entries.

In the *Schematic* window itself no value changes are allowed.

Direct Measurement

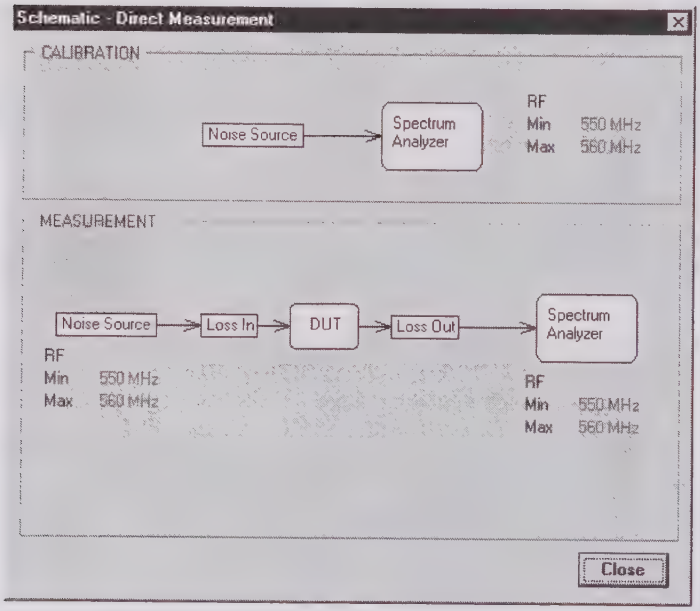


Fig. 4-15 Menu Schematic – Direct Measurement

The upper part of the window shows the test setup for the calibration. The lower part shows the test setup for the measurement proper.

With the aid of *Loss Out*, DUTs with a high gain that exceed the dynamic range of the analyzer can be easily measured. To this end, the DUT is connected to the analyzer via a known attenuator. The values of this attenuator are entered in the table *Loss Out*. These values permit the program to determine the exact values for gain and noise figure.

The additional attenuator should reduce the gain of the complete unit to below 40 dB.

Frequency-converting Measurement (fix LO or fix IF)

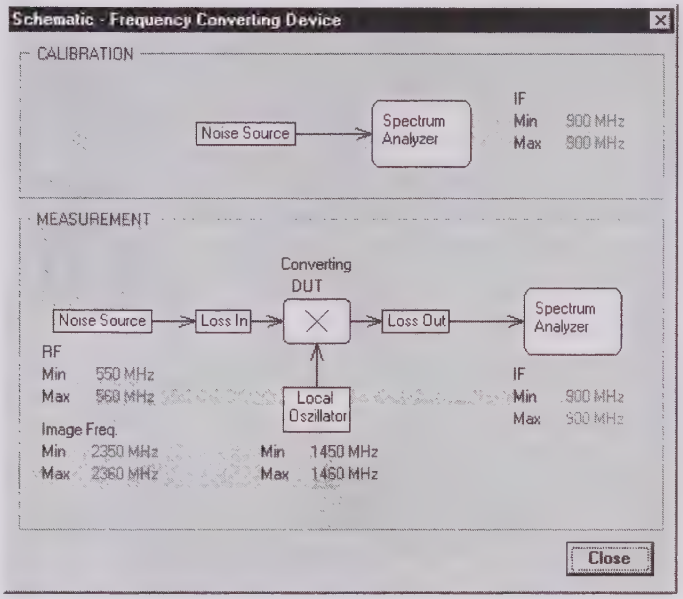


Fig. 4-16 Menu Schematic – Frequency Converting

The upper part of the window again shows the test setup for the calibration. The lower part shows the test setup for the measurement proper. The various frequency ranges covered during the measurement are displayed here.

The *Image Freq* field indicates the range of the image frequency. This permits the user to determine whether image frequency filters are required and for which frequency range the image rejection of the DUT is to be entered in the *Image Reject.* field in the main menu.

With the aid of an external attenuator, even frequency-converting DUTs with a high gain can be measured.

Edit Report (Menu Item Option / Report)

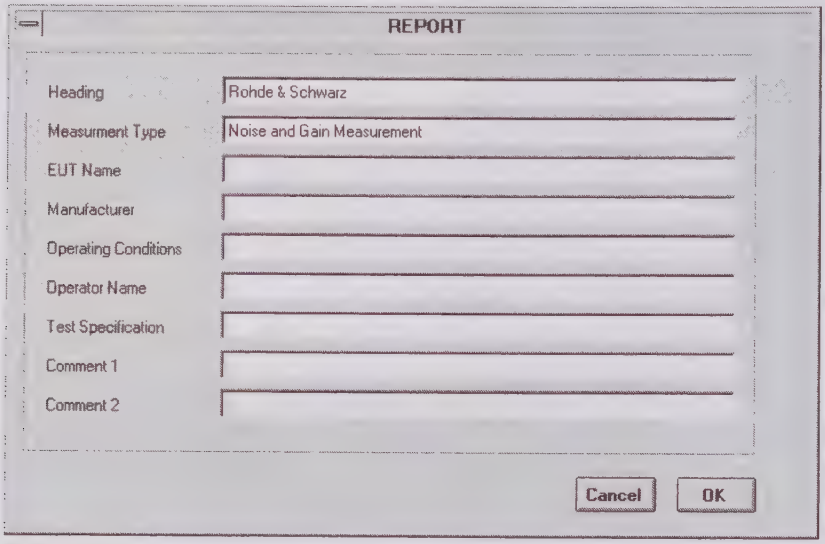


Fig. 4-17

This window permits to enters texts for documentation. They appear when printing the measured values or in the stored graphic files in WMF format. The texts can also be blanked. The option switch used for this purpose will appear after calling up the print or export WMF function.

The texts are stored using the *Save Setting* function.

INFO (Menu Item Option / Info...)

This option indicates the version number of the software. The ESC key is used to close the Info window again.

Edit Frequency List (Menu Item: Option / Edit Freq.List)

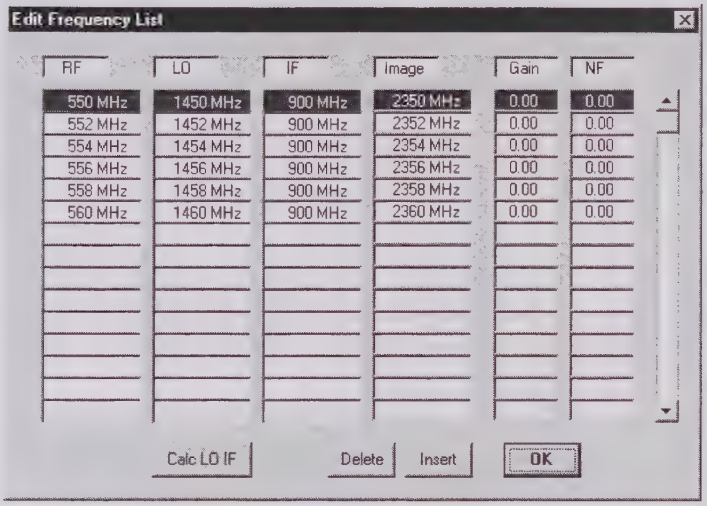

Edit Frequency List
RF
LO
IF
Image
Gain
NF
550 MHz 1450 MHz 900 MHz 2350 MHz 0.00 0.00
552 MHz 1452 MHz 900 MHz 2352 MHz 0.00 0.00
554 MHz 1454 MHz 900 MHz 2354 MHz 0.00 0.00
556 MHz 1456 MHz 900 MHz 2356 MHz 0.00 0.00
558 MHz 1458 MHz 900 MHz 2358 MHz 0.00 0.00
560 MHz 1460 MHz 900 MHz 2360 MHz 0.00 0.00
Calc LO IF
Delete
Insert
OK

Fig. 4-18 Menu Edit Frequency List

Generation of any Frequency List

In this window, the generated frequency table can be viewed and edited. It permits to delete test points with spurious. Frequency values can be varied or new values added. How to proceed for editing tables has already been dealt with in chapter 3.

After the list has been changed manually, no more changes are allowed in the field *Create Freq.List* of the main menu, since a new frequency list would be created in this case, overwriting all manual changes.

Changes can be made in the areas *RF*, *LO* and *IF*.
To generate a list with any frequency points it is sufficient to change the values in the *RF* area. By subsequently clicking on the *Calc LO IF* field, the associated frequencies in the area *LO* and *IF* are automatically adapted. These values are calculated using the setting in the *Create Freq.List* of the main menu.

In the *Image* area, the image frequency is displayed in the converting measurement.

Using Voltage-controlled Generators

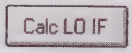
A voltage-controlled oscillator often works as local generator. If this oscillator is to be also tuned by the program, an IEC-BUS controllable voltage source is required.
The following procedure is suitable for this purpose:

- Determination of the VCO voltage values for the displayed LO frequencies.
- Changing the LO frequency values of the table into the corresponding voltages. The voltage values are entered as a frequency.
  e.g.: LO frequency : 1930 MHz associated voltage value: 2.34 V
  → the value 1930 MHZ is replaced by 2.34 Hz.

This change is now necessary for each single LO frequency value. The assignment hertz → voltage is made in the file LO_K3.GEN. There, a generator is added, which actually represents a voltage source. The entries in the file are made such that the voltage prefix of the voltage source is entered instead of the frequency prefix. The same applies to the frequency suffix, e.g. RF → U and Hz → V.

After making the entries in the frequency table, it is not allowed to make any more changes in the field "Create Freq.List" nor click on the field *Calc LO IF*, as this would overwrite all changes in the *LO* area. It is recommended to save the created table (**File / Save Setting**).

Note: *During the frequency entry in the "Create Freq.List" area, the window "Edit Frequncy List" may remain open. The data items in this window are updated with each change. Thus it is possible to observe the result of the entries immediately.*



Recalculates LO and IF. This may be required if receive frequencies (RF) have been changed.

Deletes the line marked in blue from the table.

Inserts an additional blank line at the line marked in blue.

Closes the window. Alternatively, the key combination Alt + F4 can be used. Closing of the window also updates the output graphics.

5 Noise Measurement

The program FS-K3 permits to determine the noise figure of amplifiers and converters using a spectrum analyzer of the FSE family and an additional noise source. The program uses the known noise power of the noise source as reference. By switching the 28-V supply on and off, two different noise displays are obtained on the analyzer. These measured values and the known noise power of the source permit to calculate the noise figure of the DUT.

The results of the program are only valid for the **50-Ω system**.

The program supports two measurement procedures referred to as *2nd stage correction OFF* and *2nd stage correction ON* in the following.

Furthermore, the following abbreviations are used:

Low pass:	Lowpass filter for elimination of external RF interference received by the switched +28-V supply
Noise Source:	Noise source with known ENR values.
DUT:	Device under test
Gdut[dB]:	Gain of DUT in dB
NFdut[dB]:	Noise figure of DUT in dB
NFanly[dB]:	Noise figure of analyzer in dB (without external preamplifier about 15 to 20 dB)
ENR[dB]:	ENR value of noise source in dB

2nd stage correction OFF

This method corresponds to the known Y-factor method.

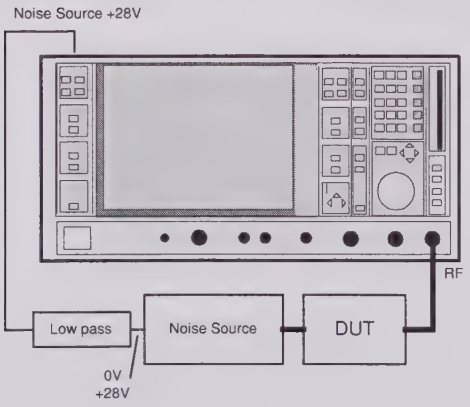


Fig. 5-1 Test setup

After entering all the parameters (frequency range, ENR values), the measurement is started by clicking on the *RUN* field in the main menu (for more details see chapter 4).

Advantage: No calibration setup required.

Disadvantage: The measured noise figure and the displayed gain are affected by the inherent noise of the analyzer. The displayed gain is additionally impaired by the absolute display error of the analyzer. The measured noise gain, however, is not invalidated by the absolute display error.

Error estimation for the noise figure:

The error caused by the inherent noise of the analyzer is the smaller, the larger the gain of the DUT. The following is true for the order of magnitude of the error:

If: Gdut[dB] > NFanly[dB] + 10 dB => error of NFdut[dB] < 0.5 dB
If: Gdut[dB] > NFanly[dB] + 20 dB => error of NFdut[dB] < 0.05 dB

It is evident that DUTs with a small gain cause higher measurement uncertainties than those with a high gain. A remedy may be to connect an external preamplifier between DUT and analyzer. Thus the accuracy of the noise measurement is increased. The display of the gain, however, is varied by the magnitude of the external preamplification (see also Chapter 6 External Preamplifier and Noise Sources).

2nd stage correction ON

This method of measurement requires two steps:

1st step: **Calibration**
Using this measurement, the program can determine the inherent noise and the absolute error of the analyzer.
After entering all the parameters (frequency range, ENR values), the calibration is started by clicking on the *CAL* field in the main menu (for more details, see chapter 4)

2nd step: **Measurement:**
The DUT is now inserted into the test setup. The measurement is started by clicking on the *RUN* field in the main menu (for more details see chapter 4).

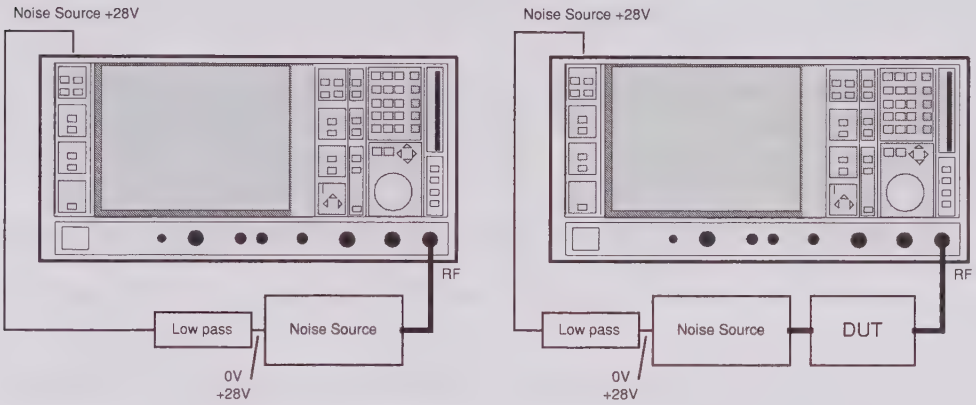


Fig. 5-2 Calibration and measurement

Disadvantage: An additional calibration is required. The calibration data can be stored using the *Save Setting* function and are therefore also available again at a later point in time.

Advantage: The analyzer noise and the absolute error are determined in the calibration. Both values are taken into account in the calculation of the measurement results. The errors of the measurement results therefore only depend on the accuracy of the ENR values of the noise source and the linearity of the analyzer. However, this error is very small so that very precise measurements are possible.

To achieve the specified accuracy, the following conditions must be met:

NFdut[dB]+Gdut[dB]	>	NFanly[dB]+3dB
ENR[dB]	>	NFanly[dB]
ENR[dB]	>	NFdut[dB]

See also chapter 6 External Preamplifiers and Noise Sources

DUTs with a Very Large Gain

If the gain of the DUT exceeds 60 dB, the total gain must be reduced by an external attenuator. The total gain of the DUT together with the external attenuator should lie within the range 10 dB to 60 dB. A total gain of 20 dB to 30 dB is recommended. For a DUT with a gain of e.g. 64 dB, it is recommended to use an external 40-dB attenuator.

In the menu item **Device** (see chapter 4, Device), the entry in the *Range* field is adapted according to the total gain (= G_{dut} – external attenuator).
The attenuation values of the external attenuator are entered in the **LOSS** menu in the area *LOSS OUTPUT*.

Inaccuracies when entering this attenuation mainly influence the measured gain. The noise figure remains to a large extent untouched.

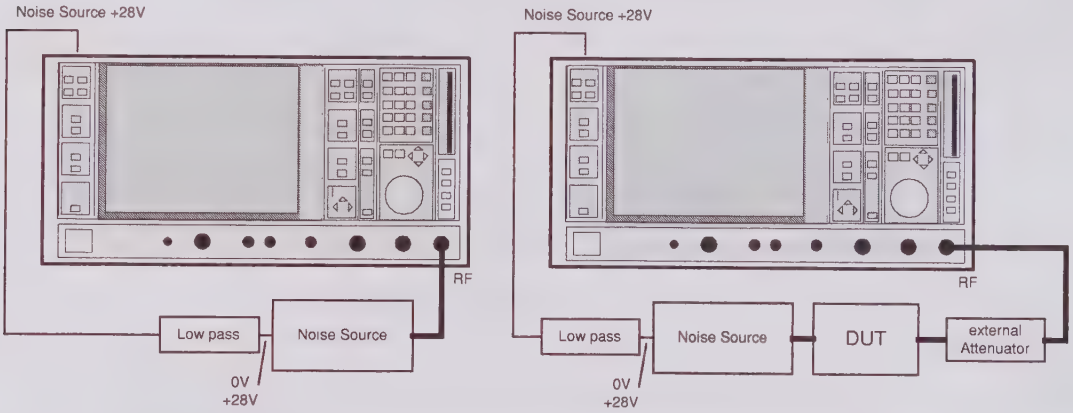


Fig. 5-3 Calibration and measurement on DUTs with a high gain

DUTs with a Very Large Noise Figure

For DUTs with a very large noise figure, there are often no noise sources with accordingly high ENR values. In this case, normal noise measuring methods can no longer be used. The total package FS-K3, however, includes the program FSE-NOISE, which also enables the measurement of these devices. With a known gain of the DUT, this program permits to determine the noise figure.

For more details see the description of FSE-NOISE

Frequency-converting Measurement

The frequency-converting measurement is used for DUTs the output frequency of which differs from the input frequency, e.g. mixers and satellite converters. The converting measurement allows many variations, which differ from each other in two criteria:

1. Fixed local oscillator frequency or fixed intermediate frequency with tracking LO frequency
2. Rejection of image frequency (SSB, DSB)

The following abbreviations will be used in the following:

RF: Input frequency
IF: Intermediate frequency
LO: Local oscillator frequency

Fixed Local Oscillator Frequency or Fixed Intermediate Frequency with Tracking LO Frequency

If a converting DUT with a fixed intermediate frequency is involved, the program FS-K3 must be enabled to vary the associated local oscillator in its frequency. This generator is controlled via the IEC bus. The required settings are made in the **Device** menu. The generator may also be an IEC-bus controllable voltage source, whose voltage in turn controls a VCO (for more details, see chapter 4 Edit Frequency List). Furthermore, one of the following two settings must be selected in the case of the fixed intermediate frequency:

fix IF LO=RF+IF or *fix IF LO=abs(RF–IF)*

If the internal computer of the analyzer is used as controller, the Option FSE-B15 is required (=second IEC-BUS connector with controller function). The IEC-BUS connector in the basic configuration is not provided with a controller function and can therefore not control external generators.

In the case of a DUT with fixed LO frequency, control by the program is not absolutely necessary. The corresponding settings are to be made in the **Device** menu (setting: manual).

Select one of the following settings in the main menu:

fix LO IF=RF+LO or *fix LO IF=abs(RF–LO*

In the main menu, the position of the intermediate frequency referred to the two other frequencies is determined. There are four possibilities:

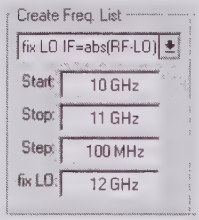
1. fix IF LO=RF+IF
2. fix IF LO=abs(RF–IF)
3. fix LO IF=RF+LO
4. fix LO IF=abs(RF–LO)

The settings are to be illustrated by means of an example.

Example:

The noise figure as well as the gain of a satellite converter with built-in 12-GHz oscillator is to be determined at an input frequency of 10 GHz to 11 GHz. The output frequency of the converter is 1 GHz to 2 GHz.

➢ The following settings are to be made in the main menu:



The settings can be checked using the menu items **Schematic** and **Option / Edit Freq.List**.

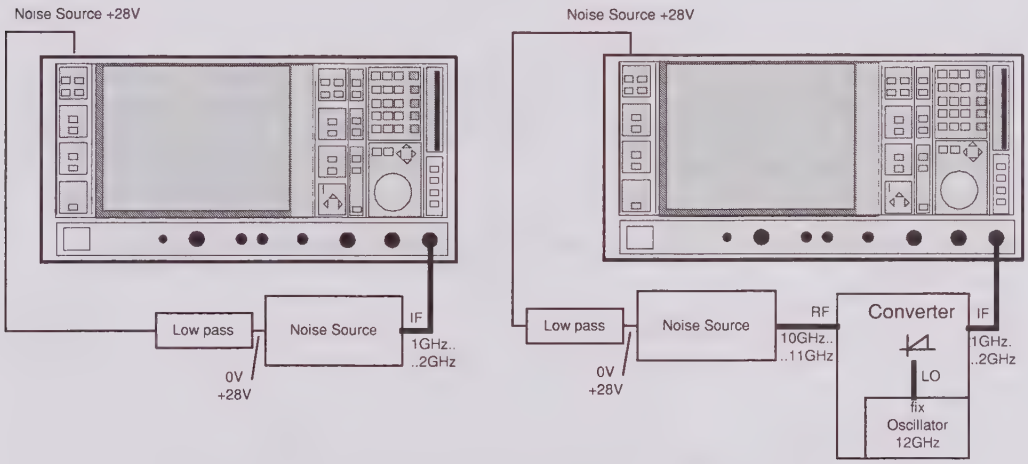


Fig. 5-4 Calibration and test setup for measurement of a satellite converter

The calibration is only required in the setting 2nd stage correction *ON*.

Image-frequency Rejection (SSB, DSB)

Frequency-converting DUTs often do not only convert the desired input frequency but also the image frequency. A broadband noise source offers noise to the DUT not only at the input frequency but also at the image frequency. If the noise power at the IF gate is measured, the origin of the noise can no longer be determined. It may have been converted both from the input and from the image frequency range. Example: IF = 100 MHz; LO-Freq. = 500 MHz; input frequency: 400 MHz; image frequency: 600 MHz

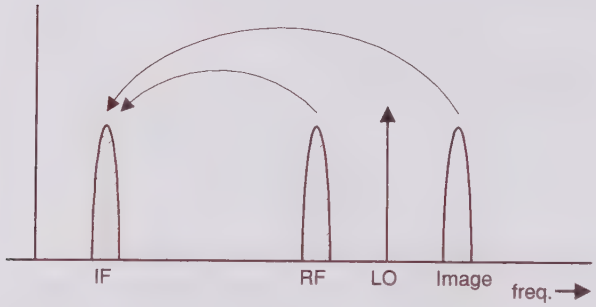


Fig. 5-5

If a DUT, which equally converts the useful signal and the image to the IF frequency, is measured using the conventional Y-factor method or with the setting *2nd stage correction ON*, a measuring error of 3 dB will be produced. The noise figure is displayed 3 dB lower and the gain 3 dB higher. The following examples help to configure the test setup such that the actual values can be measured.

a) Measurement on a single-sideband mixer (SSB = single sideband, high side-band suppression)

IF 100 MHz; LO-Freq. 500 MHz; RF 400 MHz;

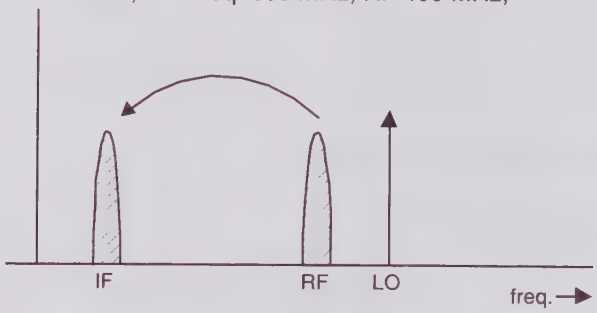


Fig. 5-6

In general, a single-sideband mixer with a very high image rejection causes only little problems. The measurement is analogous to an amplifier.

➢ Enter 999 dB in the "*Image Reject*" field.

Gain and noise figure are displayed correctly.

b) Measurement on a mixer without sideband suppression (DSB = double sideband)

IF: 100 MHz; LO-Freq.: 500 MHz; RF: 400 MHz; Image-Freq.: 600 MHz

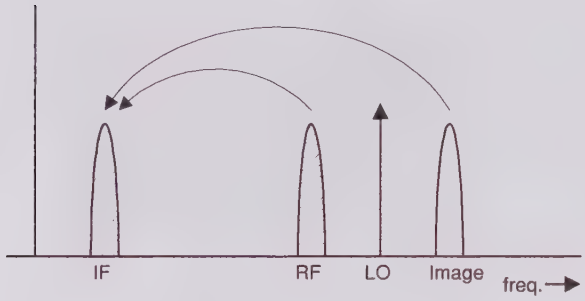


Fig. 5-7

It input and image frequecy are converted in with the same application, an error in measurement of 3 dB if the image rejection is not taken into account.

➢ Set 999 dB (SSB) in the "*Image Reject*" field (incorrect setting).
(This corresponds to the measurement result of conventional noise test sets without correction).

With this setting, the noise figure is measured 3 dB too low and the gain 3 dB too high.

➢ Enter a value of 0 dB in the *Image Reject* field.

With this setting, gain and noise figure are measured correctly.

c) Measurements on a mixer with an average sideband suppression
(in the example 4dB)

IF: 100 MHz; LO-Freq.: 500 MHz; RF: 400 MHz; Image-Freq.: 600 MHz

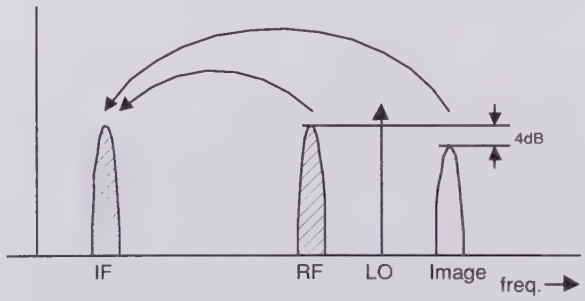


Fig. 5-8

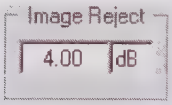
For measurements on a mixer with a low image-frequency rejection, a measuring error of 0 to 3 dB will be obtained if the image-frequency rejection is not taken into account.

Wrong setting:
➢ Enter a value of 999 dB in the *Image Reject* field.

With this setting, the noise figure is measured 0 to 3 dB too low and the gain 0 to 3 dB too high (this corresponds to the measurement result of conventional noise test sets without correction).

➢ Correct setting:

➢ A value of 4 dB is entered in the *Image Reject* field.



With this setting, gain and noise figure are measured correctly.

d) Measurements on a mixer with unknown sideband suppression

IF: 100 MHz; LO-Freq.: 500 MHz; RF: 400 MHz; Image-Freq.: 600 MHz

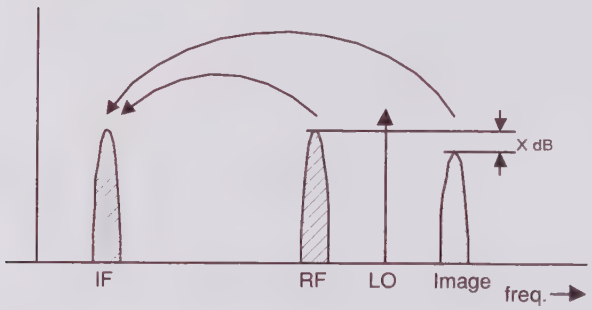


Fig. 5-9

If the image rejection is not known, the program **FS-Noise** can be used. However, the gain of the DUT must be known. If an additional filter is used, the program **FS-K3** can still be further used.

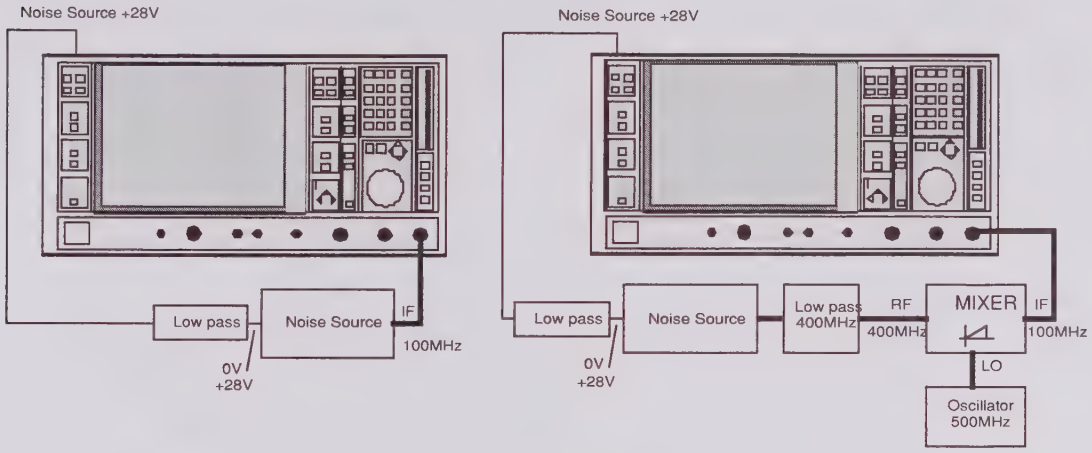


Fig. 5-10 Calibration and test setup for the above example

In this test setup, a lowpass prevents noise from the noise source from being fed in at the image frequency. Depending on the position of the frequency bands, a highpass or bandpass may also be necessary for the RF frequency instead of the lowpass. The main thing is that noise from the noise source is not converted by a further receive path of the mixer. The noise of the noise source at the receive frequency must not be reduced. The insertion loss must be considered, if applicable.

With this test setup, the measurement on a mixer without sideband suppression corresponds to the measurement on a single-sideband mixer.

➢ Set 999 dB in the *Image Reject* field.

Gain and noise figure are measured correctly.
If the characteristics of the filter are to be taken into account, the insertion loss of the filter at the RF frequency can be entered in the **LOSS** menu. If the actual filter suppression at the image frequency is to be considered as well, do not enter 999 dB, but the actual attenuation in the "Image Reject" field.

e) Measurements on harmonics mixer

In the harmonics mixer, the input signals are not only converted to the IF by the wanted harmonic, but also by the harmonic of the LO signal produced in the mixer. In many cases, the mixer even features a lower conversion loss in the case of unwanted harmonics. For measurements on mixers like that, a bandpass filter must be used to make sure that that there is only noise at the desired input frequency at the input of the DUT. The measurement is similar to example c.

If the gain is known, the Software **FS-Noise** can also be used. The use of a bandpass filter will then no longer be necessary.

6 General Notes on the Measurement

External Preamplifiers and Selection of Appropriate Noise Sources

To obtain correct noise measurement results, the noise figure and the gain of the DUT must be in a particular ratio to the noise figure of the analyzer and the ENR values of the noise source. The ratios have already been given in chapter 5, Noise Measurement. Since, in practice, the values for these ratios are often not known or these conditions cannot be fulfilled, this chapter will show how to check the test setup using three simple tests.

Test 1:

The noise power at the output of the DUT should be greater than the input noise power of the analyzer. This corresponds to the condition: $NF_{dut}[dB]+G_{dut}[dB] > NF_{anly}[dB]$

Test setup:

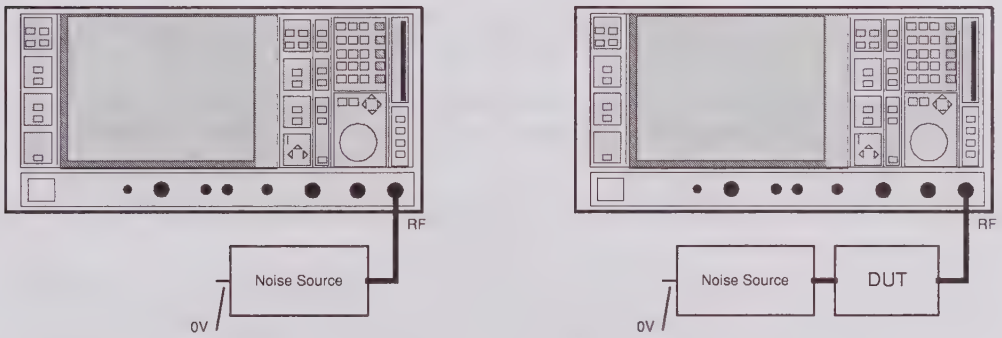


Fig. 6-1 Measurement of inherent noise and noise with DUT

The noise source is not in operation. It only serves as pure 50-Ω termination.
After the analyzer has been initialized, the two values can be read off using the marker function:

Evaluation of the level difference of the two measurements for the setting 2nd stage correction OFF:

<5 dB	Measurement does not make sense, an external preamplifier is recommended.
>10 dB	Error of measured noise figure: Measurerment accuracy acc. to FS-K3 data sheet + 0.5 dB
>20 dB	Error of measured noise figure: Measurerment accuracy acc. to FS-K3 data sheet + 0.05 dB

Evaluation of the level difference of the two measurements for the setting 2nd stage correction ON:

>5 dB	Measurement makes sense; error of noise figure: see specification in data sheet
0.5 dB to 5 dB	Measurement possible with restricted accuracy, an external preamplifier is recommended
<0.5 dB	Measurement only possible with restrictions. Presumably, the DUT is an attenuating DUT with little noise power of its own. The measurement of the noise figure may be subject to larger fluctuations, although the gain displayed may be very precise.

Measurements with an external preamplier may require the reference level to be varied (see chapter 4, Device Settings).

Test setup with external preamplifier:

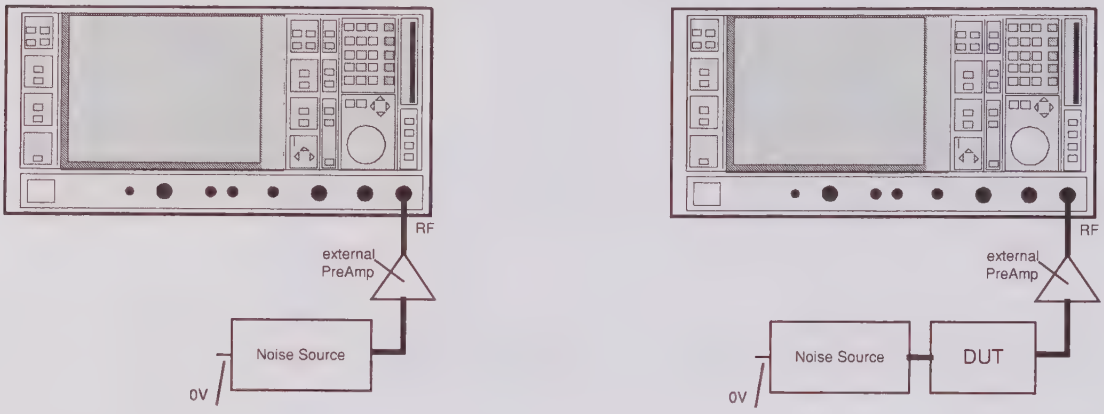


Fig. 6-2 Measurement of inherent noise of test system with external preamplifier; measurement of noise power of test system with DUT

The level difference between the two measurements is evaluated according to the above example.
If there is still no considerable level difference between the two test setups, the following items are to be checked:

- Is the RF ATT set too high so that the noise figure of the analyzer is no longer sufficient?
- Is the noise superimposed by spurious? (see chapter 6, RF Interference)
- Is the resolution bandwidth RBW selected too large so that the internal local oscillator of the analyzer impairs the measurement result? (see chapter 6, Resolution bandwidth RBW)
- Is the DUT switched on, thus producing inherent noise? Passive DUTs and DUTs with low output noise power can only be measured with restricted accuracy using this test procedure or not at all.

Test 2:

The noise power of the noise source should be greater than the input noise power of the DUT. This corresponds to the condition: ENR[dB] > NFdut[dB]

Test setup:

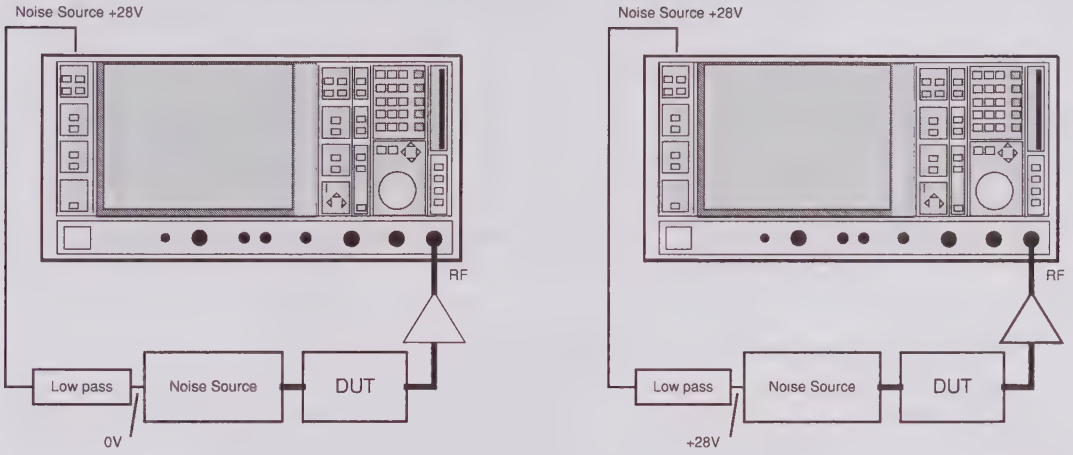


Fig. 6-3 Measurement with noise source switched on and off

The noise source can be switched on or off on the analyzer using the function [**SETUP:** SERVICE: NOISE SOURCE ON/OFF]. However, it is also possible to disconnect or plug in the BNC cable for the voltage supply of the noise source.

Evaluation of the level difference between the two measurements for the setting *2nd stage correction OFF*

>5 dB	Measurement makes sense; noise figure error see Test 1
0.5 dB to 5 dB	Measurement possible with restricted accuracy, noise source with higher ENR values or external preamplifier is recommended

Evaluation of the level difference between the two measurements for the setting *2nd stage correction ON*

>5 dB	Measurement makes sense; noise figure error: specification in data sheet
0.5 dB to 5 dB	Measurement possible with restricted accuracy, noise source with higher ENR values or external preamplifier is recommended

If there is no considerable level difference between the two measurements, the following items are to be checked:

- Is the +28-V supply of the noise source switched correctly (check using voltmeter)
- Check the items of Test 1.

Selection of an appropriate noise source:
Noise sources can be obtained with different ENR values. In most cases, noise sources can be divided into 3 categories.

a) Noise sources with low ENR values (5 to 7 dB):

Range of application: Measurement of amplifiers with a very low noise figure (<3 dB).

Advantage: Due to the low noise increase, only a small part of the dynamic range of the analyzer is utilized. Thus, linearity errors are minimized.
Noise sources with low ENR values hardly show a difference in impedance between off and on status. They always constitute an excellent 50-Ω termination for the DUT.

Disadvantage: Due to the low noise power of the source, only DUTs with a low noise figure can be measured. Furthermore, calibration is not possible without external preamplifier, since the noise power of the noise source lies far below the input noise of the analyzer.
However, an uncalibrated measurement of devices with a gain greater than 30 dB would be possible.

b) Noise sources with average ENR values (13 to 16 dB):

Range of application: Standard noise source; measurement of amplifiers with noise figure (<15 dB).

Advantage: Most measurements can be performed using this noise source.

Disadvantage: A calibration (2nd stage correction ON) is still possible.

c) Noise sources with high ENR values (20 to 30 dB):

Range of application: Measurement of amplifiers with high noise figure (10 to 30 dB).

Advantage: This noise source can be used to measure DUTs with a high noise figure.
A calibration (2nd stage correction ON) is possible even without preamplifier.

Disadvantage: Due to the high noise power, a larger part of the dynamic range of the analyzer is utilized. This may lead to linearity errors (<0.1dB).
Furthermore, these noise sources show a higher difference in impedance between off and on status, which may also lead to errors in measurement.

If the noise figure of the DUT is very high and no appropriate noise source is available, the program **FSE-NOISE** should be used. This program is included in the total package **FS-K3**. With known DUT gain, this program permits to determine the noise figure of devices, which is no longer possible using normal noise measuring methods.

Test 3 (*only for 2nd stage correction ON*)

The noise power of the noise source should be greater than the inherent noise power of the analyzer. This corresponds to the condition: ENR[dB] > NFanly[dB]

Test setup:

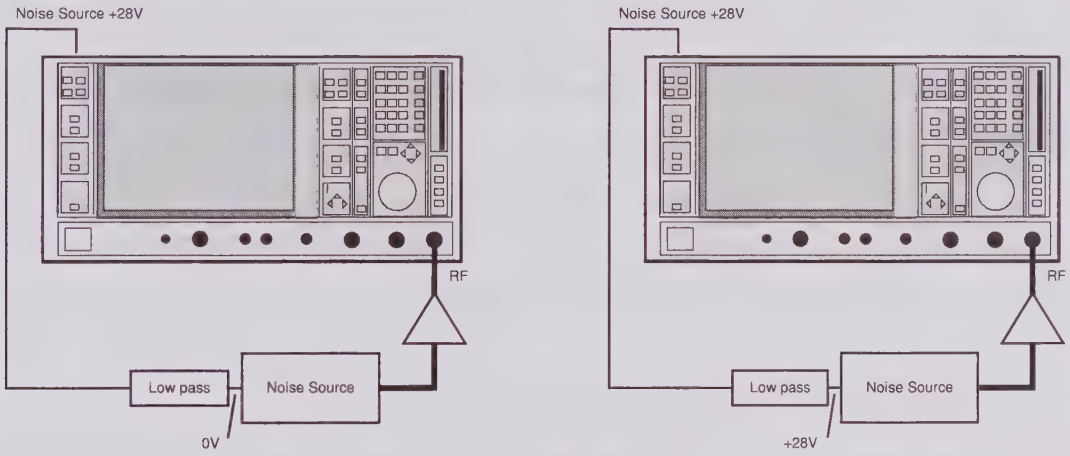


Fig. 6-4 Measurement with noise source switched on and off

The noise source can be switched on or off on the analyzer using the function [**SETUP:** SERVICE: NOISE SOURCE ON/OFF]. However, it is also possible to disconnect or plug in the BNC cable for the voltage supply of the noise source.

Evaluation of the level difference between the two measurements for: *2nd stage correction ON*:

>3 dB	Measurement makes sense; noise figure error see specification in data sheet
0.5 dB to 3 dB	Measurement possible with restricted accuracy, noise source with higher ENR values or external preamplifier is recommended.

RF Interference

One of the most frequent causes of faulty measurements is RF interference due to external interference sources. The analyzer is an appropriate device for detecting such interference sources.

To this end, the SPAN of the analyzer is increased. Thus, on overview of the signals in the relevant frequency range is obtained. Besides, the bandwidth RBW is reduced so that small signals may protrude visibly from the noise. Even if interference signals disappear in the noise of the test bandwidth, they still contribute to inaccuracies. They can be detected by means of narrow bandwidths.

The search function permits to quickly switch over to normal SWEEP mode with reduced bandwidth.

The Init function resets the analyzer and enables further noise measurements.

RF interference may enter the test setup in two ways:

- Interference directly received by the DUT or interference via the DUT supply. This can be avoided by shielding and filtering.
- Interference via a ground loop. The test setup consists of an unavoidable ground loop with the following ground circuit: analyzer, noise source, DUT, analyzer.

To find out the cause, disconnect the voltage supply from the noise source and thus open the ground loop. If the spurious disappear, this implies problems with the ground loop.

To cause the spurious to disappear, it is often sufficient to thread the BNC cable of the +28-V supply several times through a ferrite ring with high permeability. This results in a high-impedance ground loop already for frequencies above 500 Hz. The effect of interference is thus considerably reduced. The efficiency of this measure depends very much on the permeability of the ferrite ring and the number of windings.

Possibilities for Noise Averaging

Noise is naturally a signal with heavy statistical fluctuations. In order to obtain a stable display nevertheless, the noise must be averaged and smoothed. The analyzer offers several possibilities for this purpose.

Selection of the Resolution Bandwidth (RBW)

The selection of the resolution bandwidth is very important. The larger it is selected, the wider the frequency range of the noise over which averaging is possible at the same time. A bandwidth of 1 MHz already provides very stable results. However, the resolution bandwidth of the analyzer must not exceed the bandwidth of the DUT. This might result in faulty measurements.

A restriction of the bandwidth may also be necessary if there are a lot of unavoidable spurious lines between which the measurement is to be made. Reduce the bandwidth to such an extent that the measurement is no longer affected by spurious.

The input frequency plays a further role in the selection of the resolution bandwidth. If the test frequency lies below about 3 MHz, the bandwidth must be reduced so that the local oscillator is ignored. Smaller resolution bandwidths result in longer settling times. The SWEEP TIME of the analyzer must therefore be increased.

The following table will be helpful for the setting. However, it provides only approximate values. The settings can still be optimized depending on the test setup.

Table 6-1

RF Frequency	RBW	VBW	SWEEP TIME	AVERAGE
> 400 Hz	100 Hz	2 Hz	500 ms	10
> 2 kHz	500 Hz	10 Hz	200 ms	10
> 10 kHz	1 kHz	10 Hz	200 ms	10
> 100 kHz	10 kHz	30 Hz	100 ms	10
> 200 kHz	20 kHz	30 Hz	100 ms	10
> 500 kHz	50 kHz	30 Hz	100 ms	10
> 1 MHz	100 kHz	30 Hz	100 ms	5
> 7 MHz	1 MHz	30 Hz	100 ms	1

Caution: *With bandwidths below 1 kHz, the internal local oscillator may cause an IF overload. This is indicated by the instrument in analyzer mode. As a remedy, switch off the automatic reference level setting. Then manually increase the reference level until no overload will occur any longer.*

Selection of the Video Bandwidth (VBW)

The video filter corresponds to a lowpass filtering of the rectified input signal. The smaller this filter is selected, the more the fluctuations of the input signal are smoothed. However, narrow video filter settings result in longer settling times. Hints for the setting are to be found in the table under *Selection of the Resolution Bandwidth (RBW)*.

Average

The *Average* field permits to set the number of *Sweeps* for averaging. A sweep consists of 500 test points, which are already averaged using the *MEAN MARKERS*. The average function can be used to multiply the number of these test points. The stability of the measured value is thus increased. However, the total measuring time also increases to the same extent.

SWEEP TIME

The field *Sweep Time* permits to set the duration of a sweep. This value should be high enough to ensure the settling of the video filter.

The following formula can be used to calculate an approximate value:

SWT > 5 / VBW

The following abbreviations are used:

SWT	SWEEP TIME in seconds
VBW	Video bandwidth in hertz
RBW	Resolution bandwidth in hertz

Prerequisite RBW > VBW

For a video bandwidth of 10 Hz, a minimum *sweep time* of 0.5 s is thus obtained. The *sweep time* may also be selected higher, which often has a favorable effect on the stability of the display. The sweep time can as well be reduced if the number of averages is increased to the same extent.

7 List of Files

Installation

The installation program copies the following files:

System directory

COMDLG.DLL	VB4.0
COMPOBJ.DLL	VB4.0
OC25.DLL	VB4.0
OLE25.DLL	VB4.0
OLE2DISP.DLL	VB4.0
OLE2NLS.DLL	VB4.0
STORAGE.DLL	VB4.0
THREED16.OCX	VB4.0
TYPELIB.DLL	VB4.0
VB40016.DLL	VB4.0
GRAPHS16.OCX	Graphics Server
GSW16.EXE	Graphics Server
GSWAG16.DLL	Graphics Server
GSWDLL16.DLL	Graphics Server

Working directory

FS-K3.EXE	Program FS-K3
FS-ENR.EXE	Program FS-ENR
FS-NSE.EXE	Program FS-Noise
INIT.K3	Initialization file for program FS-K3
INIT.K3E	Initialization file for program FS-ENR
INIT.K3N	Initialization file for program FS-Noise
INIT.ENR	Initialization file ENR values for program FS-K3
INIT_ENR.ENR	Initialization file ENR values for program FS-ENR
INIT_NSE.ENR	Initialization file ENR values for program FS-Noise
LO_K3.GEN	Generator file for program FS-K3
K3EXE.ICO	Icons for the programs FS-K3, FS-ENR, FS-Noise
README.TXT	"Readme" test file

Structure of the Files

File GRAPH-K3.WMF

Files with the ending ".WMF" include graphics data in the metafile format. This format can be read in as graphics by various word processing programs (e.g. MS-Word 6.0) and thus embedded in the documentation.

These files can be generated using the menu item: **File / Export WMF**

File FS-K3.TXT

Files with the ending ".TXT" contain measured data in the ASCII format. This format can be loaded as text and processed by various word processing programs (e.g. MS-Word 6.0). These files can be generated using the menu item **File / Export TXT**.
Structure of the ASCII files for measurement results of the FS-K3 Software:

Frequency	Gain	AF	Temp
550 MHz	12.37 dB	4.64 dB	555.1 K
552 MHz	12.39 dB	4.64 dB	554.5 K
554 MHz	12.34 dB	4.67 dB	560.7 K
556 MHz	12.37 dB	4.62 dB	550.3 K
558 MHz	12.30 dB	4.61 dB	549 K
560 MHz	12.22 dB	4.63 dB	551.3 K

File FS-K3.DAT

Files with the ending ".DAT" contain measured data in a format that can be read by spreadsheet routines (e.g. MS-Excel). For data separation, the comma "," is used. The point is used as decimal separator. The read-in routine of the spreadsheet routine must be configured accordingly. Depending on the spreadsheet routine, the country setting may have to be changed.
These files can be generated using the menu item **File / Export DAT**.

Structure of these files:

550000000,12.3685296755035,4.64486848690343,555.054748740085
552000000,12.3929865945534,4.64222130662768,554.53981458251
554000000,12.3355694411116,4.67382043780471,560.70706912577
556000000,12.367778226743,4.62022423189995,550.273023704513
558000000,12.3000724807838,4.61344193596912,548.961809110108
560000000,12.2227168292443,4.62546305890728,551.287243622308

Order of data: frequency, gain, noise figure, equivalent noise temperature

File LO_K3.GEN

This file contains the relevant IEC-bus (GPIB) commands of the individual generators. This file can be edited and supplemented using an ASCII editor.
File structure:

"SMHU", "RF", 1e6, "MHZ", "LEV", "DBM", -1, "*RST"

Each line of this file represents a generator. Each line consists of exactly 8 entries separated from each other by a comma.
Meaning of the individual entries:

1) "SMHU" Name of generator, quotation marks are required; this entry also appears in the generator selection menu of the Software FS-K3

2) "RF" Prefix of IEC-bus command for frequency setting;
quotation marks are required;
Caution: Spaces might be required

3) 1e6 Factor of the frequency unit e.g. 1e6 for MHz; 1e3 for kHz; 1 for Hz;
no quotation marks;
The frequency unit is defined in item 4) (suffix).

4) "MHZ" Suffix of IEC-bus command for frequency setting;
Quotation marks are required;
Caution: Spaces might be required

5) "LEV" Prefix of IEC-bus command for level setting;
Quotation marks are required;

Caution: Spaces might be required.

6) "DBM" Suffix of IEC-bus command for level setting;
Quotation marks are required;
Caution: Spaces might be required

7) -1 Terminator for the data transmission. In this case, no terminator is transmitted. However, some generators require 10 (new line) or 13 (carriage return) as a terminator. Then, –1 must be replaced by 10 or 13. The respective character is appended to the end of each command by the program.

8) "*RST" Reset command of the generator. It is sent to the generator when clicking on the field *Init* (in the area **LOCAL GENERATOR** of the menu **Device**). This initialization sequence may consist of several commands. The individual commands are to be separated by a semicolon ";" (e.g.: "*RST;LEV ON; SPEC09").
It is thus possible to generate an individual initialization that contains all important parameters.

8 FS-ENR

Overview

The program FS-ENR is included in the program package FS-K3 and can be started using the respective icon. The operation is to a large extent identical with program FS-K3. The program FS-ENR permits to compare two noise sources with each other. One noise source is used as reference for calibration of the test setup. The calibrated test setup can subsequently be used to measure further noise sources.

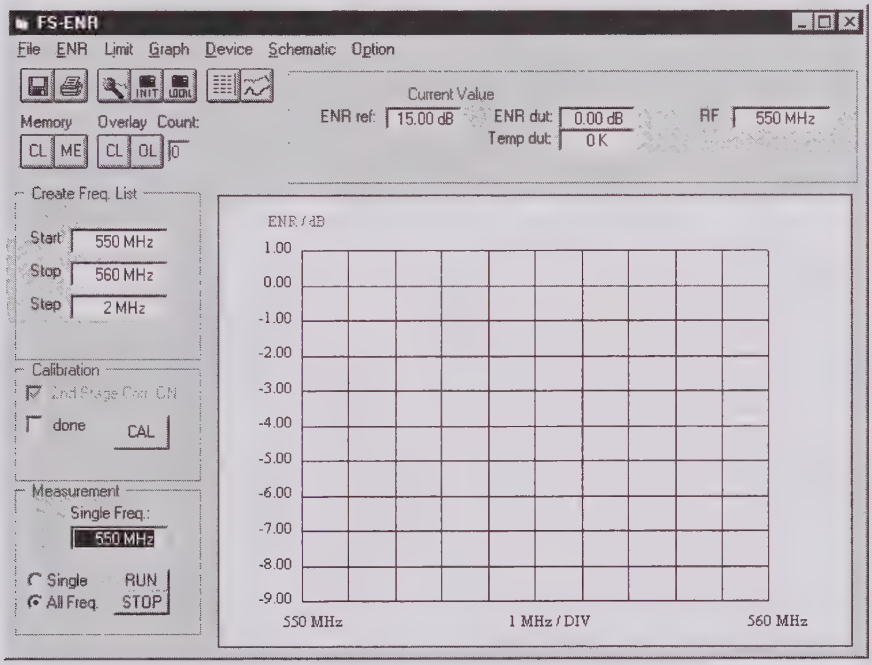


Fig. 8-1 FS-ENR menu

All results of the program are only valid for the 50-Ω system.
The output of the ENR values is in "dB". The equivalent noise temperature can as well be displayed in Kelvin "K".

The use of this program always requires calibration of the test setup with a known noise source. The ENR values of this reference noise source are to be entered in the menu item "ENR".

Noise Source Measurement

Test setup:

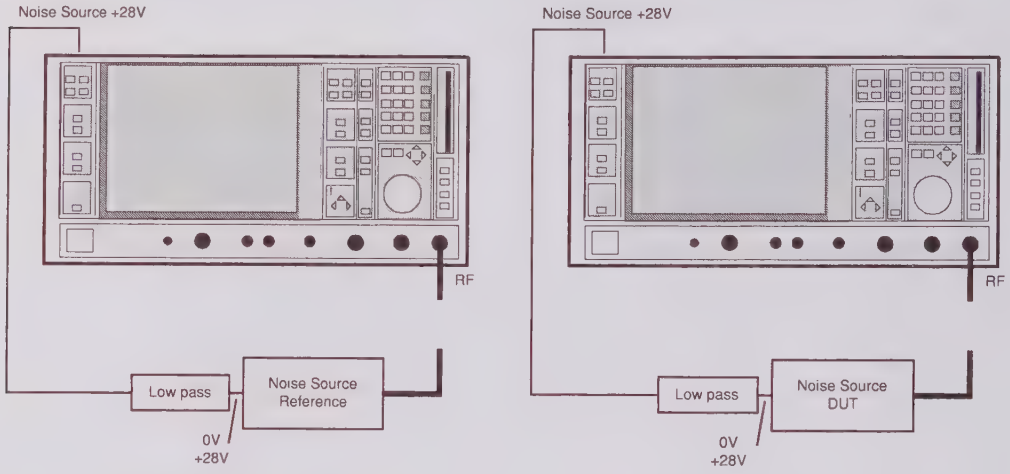


Fig. 8-2 Calibration and measurement

The calibration is made with the noise source that is to be used as reference. Then the reference noise source is replaced by the unknown noise source, the ENR values of which are to be determined. To increase the accuracy and obtain a stable display, an external preamplifier should always be used for the measurement of noise sources.

After all parameters have been set according to the instructions given in the FS-K3 manual, the calibration is started by clicking on the *CAL* button. The measurement itself is started by clicking on the *RUN* button.
Depending on the setting, the measurement results are displayed graphically or as numerical values.

9 FS-NOISE

Overview

The program FS-NOISE is included in the program package FSE-K3 and can be started using the respective icon. Its functions correspond to a large extent to the program FSE-K3. However, the program FS-NOISE does not indicate gain or noise figure. On the other hand, it permits exact measurement of the noise power at the output of a DUT. If the gain of the DUT is known, the noise figure can be calculated from these two values.

Fig. 9-1 FS-Noise menu

The results of the program are only valid for the 50-Ω system.
The noise power is output in dBm/Hz.

The use of this program always requires the calibration of the test setup using a noise source. The ENR values of this noise source are to be entered under the menu item ENR.

Amplifier Measurement

Test setup:

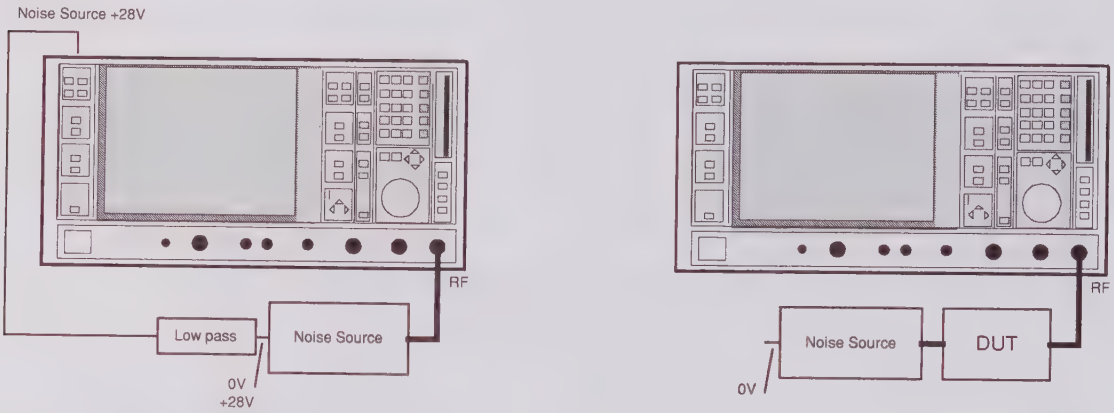


Fig. 9-2 Calibration and measurement

A noise source is only required for the calibration of the test setup.

In the measurement itself, the noise source is without function. The noise source drawn in in the test setup Measurement only serves as termination. It can as well be replaced by a 50-Ω termination.

After all the parameters have been set according to the instructions given in the manual FSE-K3, the calibration is started by clicking on the CAL button. The measurement itself is started by clicking on the RUN button.

Evaluation of the result:

G_{dut}[dB]: Gain of the DUT in [dB]
NF_{dut}[dB]: Noise figure of the DUT in [dB]
N_{dut}[dB]: Output noise power of the DUT[dBm/Hz]
-174dBm/Hz: Noise power of a 50-Ω resistor at room temperature

$NF_{dut}[dB] = N_{dut}[dBm/Hz] - 174\ [dBm/Hz] - G_{dut}[dB]$

The gain of the DUT must be determined manually using an additional generator or a network analyzer (e.g. ZVR).

External preamplifiers should be used according to the instructions in the manual FS-K3.

Frequency-converting Measurement

This program also enables the measurement of frequency-converting devices.

The noise power of the intermediate frequency is measured. All frequencies specified in the program refer to the IF. An external generator cannot be controlled. The measurement corresponds to the setting fix LO of the FS-K3. The program itself ignores any difference between converting measurement and direct measurement.

Test setup:

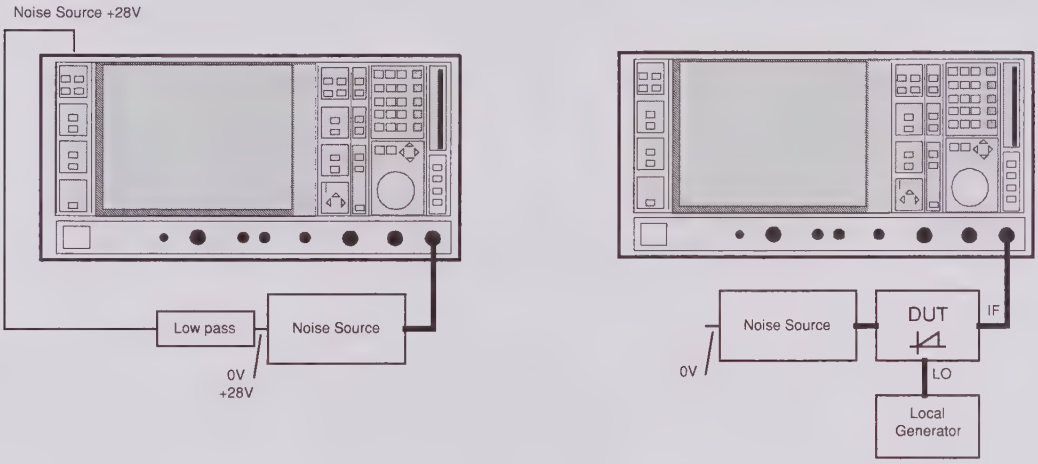


Fig. 9-3 Calibration and measurement; both measurements are performed at the IF

A noise source is only required for calibration of the test setup.

In the measurement itself, the noise source is without function. The noise source drawn in in the test setup Measurement only serves as termination. It can as well be replaced by a 50-Ω termination.

There is no setting for a frequency-converting mode. In the RF field, the IF is entered. The parameters (e.g. ENR) are set according to the instructions given in the manual FSE-K3.

The noise figure is calculated according to the above equation.
The gain of the DUT can be determined using an additional generator or a network analyzer (e.g. ZVR) for the frequency-converting measurement.

Amplifier Measurement

Test setup:

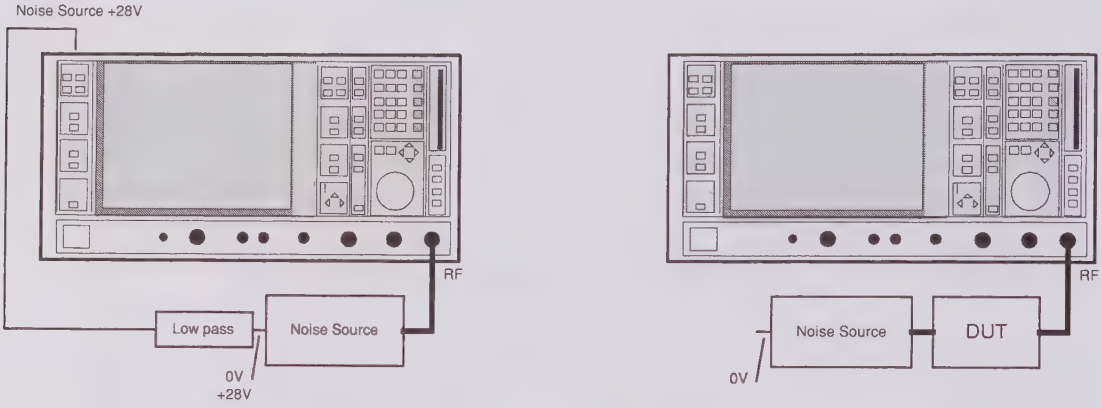


Fig. 9-2 Calibration and measurement

A noise source is only required for the calibration of the test setup.

In the measurement itself, the noise source is without function. The noise source drawn in in the test setup Measurement only serves as termination. It can as well be replaced by a 50-Ω termination.

After all the parameters have been set according to the instructions given in the manual FSE-K3, the calibration is started by clicking on the CAL button. The measurement itself is started by clicking on the RUN button.

Evaluation of the result:

G_{dut}[dB]: Gain of the DUT in [dB]
NF_{dut}[dB]: Noise figure of the DUT in [dB]
N_{dut}[dB]: Output noise power of the DUT[dBm/Hz]
-174dBm/Hz: Noise power of a 50-Ω resistor at room temperature

$NF_{dut}[dB] = N_{dut}[dBm/Hz] - 174\ [dBm/Hz] - G_{dut}[dB]$

The gain of the DUT must be determined manually using an additional generator or a network analyzer (e.g. ZVR).

External preamplifiers should be used according to the instructions in the manual FS-K3.

Frequency-converting Measurement

This program also enables the measurement of frequency-converting devices.

The noise power of the intermediate frequency is measured. All frequencies specified in the program refer to the IF. An external generator cannot be controlled. The measurement corresponds to the setting fix LO of the FS-K3. The program itself ignores any difference between converting measurement and direct measurement.

Test setup:

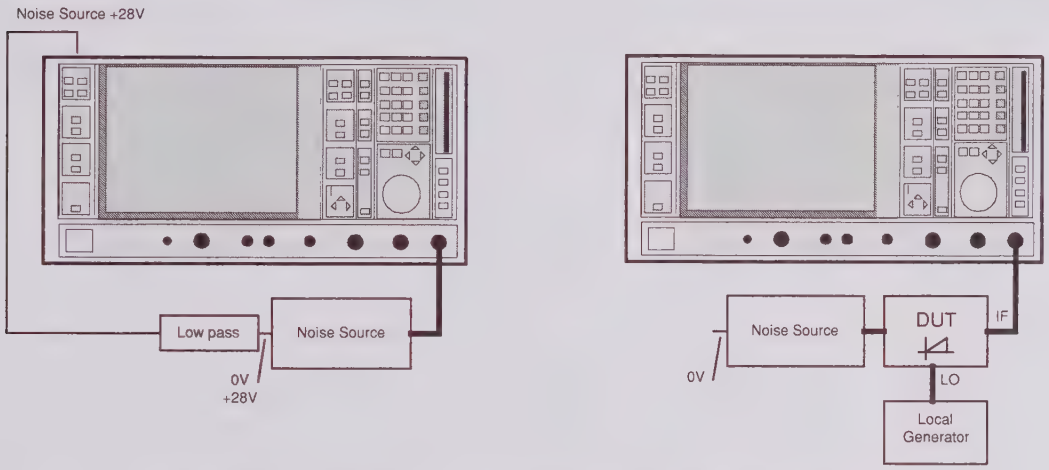


Fig. 9-3 Calibration and measurement; both measurements are performed at the IF

A noise source is only required for calibration of the test setup.

In the measurement itself, the noise source is without function. The noise source drawn in in the test setup Measurement only serves as termination. It can as well be replaced by a 50-Ω termination.

There is no setting for a frequency-converting mode. In the RF field, the IF is entered. The parameters (e.g. ENR) are set according to the instructions given in the manual FSE-K3.

The noise figure is calculated according to the above equation.
The gain of the DUT can be determined using an additional generator or a network analyzer (e.g. ZVR) for the frequency-converting measurement.

Comparison between FS-K3 and FS-NOISE

This section compares the advantages and disadvantages of both programs.

FSE-K3

Advantages: The noise figure and the gain are immediately output. An additional determination of the gain is not necessary.

Disadvantages: A DUT whose noise figure is very much greater than the ENR values of the noise source cannot be measured.

In the case of the converting measurement, the magnitude of the image rejection affects the measurement results.

FS-NOISE

Advantages: Devices with a very large noise figure can be measured.
With a frequency-converting measurement, a missing image rejection does not cause errors in measurement. The image rejection need not be known.

Disadvantages: The noise figure is not displayed directly, but must first be calculated.
For calculating the noise figure, the gain of the DUT must be known. It must be determined with the aid of other test methods and test setups. The accuracy of the noise figure depends to a large extent on the accuracy of the gain measurement. Since the test setup must be changed for measuring the gain, this may cause the impedance conditions to be changed. This means that the DUT may feature a different gain in the test setup for the noise power measurement from that for the gain measurement.
This program does not take into account external losses.

Summary: Each of the two procedures offers some advantages. The program FSE-K3 uses test procedures which are also used in noise test sets of other manufacturers. Furthermore, the program FS-NOISE extends the range of application to DUTs which have not been covered so far. The use of the two programs permits to make reliable statements about the DUT.

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